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EPITOME
OF
CHEMISTRY,
IN
THREE PARTS.

PART I.

Intended to facilitate to the Student, the Acquiſition of Chemical Knowledge, by minute Inſtructions for the Performance of Experiments.

PART II.

Directions for the Analyſis of Mineral Waters; of Earths and Stones; of Ores; of Metals; and of Mineral Bodies in general.

PART III.

Inſtructions for applying Chemical Teſts and Re-agents to various uſeful Purpoſes.

BY WILLIAM HENRY.

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PRINTED AND SOLD BY JAMES HUMPHREYS,
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PREFACE.

THE ſmall Volume, which I now offer to the 'ublic, is one of humble pretenſions : yet its plan and obcts appear to me ſufficiently diſtinct, from thoſe of every her compendium of chemiſtry, to authorize the addition one more to the extenſive liſt of elementary works. The Chemical Pocket Book" of Mr. Parkinſon, and the Deſcription of a Portable Cheſt of Chemiſtry," tranated from the German of Gottling, and publiſhed in the ar* 1791, *might, perhaps, from the ſimilarities of title nd ſize, be ſuppoſed to have precluded the neceſſity of his publication. A very curſory compariſon, however, Mr. Parkinſon's work, with this manual, will evince hat the plan and objects of the two books are totally difrent. To the work of Mr. Gottling, the preſent bears, ndeed, a nearer reſemblance, but the coincidence is not ch, as to ſuperſede the utility of this Epitome. The enueration of teſts for mineral waters; the inſtructions for pplying theſe re-agents; and the rules for detecting adulerations, are ſubjects common to both. But the progreſs f Chemical knowledge, during the laſt ten years, has*

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* *This Work may be had of the Printer hereof, embelliſhed with Plates of œconomical Laboratories, &c. &c.*

been ſo rapid, as to enable me to make numerous additions to the information of Mr. Gottling; and to induce me materially to vary the arrangement, under which it was offered. It may be added, that the ancient Nomenclature of chemiſtry, employed throughout Mr. Gottling's work, muſt render it nearly unintelligible to ſtudents of the reformed ſyſtem.

The arranged ſeries of experiments was ſuggeſted to me as proper for publication by a written catalogue, which I drew up, more than two years ago, of the experiments performed during my courſe of chemical lectures. This I deem it neceſſary to ſtate; becauſe ſomething ſimilar is to be found in an excellent manual, lately publiſhed by Bouillon la Grange.

In a work, profeſſedly compiled from others, new and original information is not to be expected; and it cannot be neceſſary to quote all the authorities for facts. If there be any one author, to whom I owe moſt, it is certainly to Mr. Kirwan, whoſe intereſting and maſterly works comprehend almoſt every ſubject of chemical enquiry. The directions for analyzing minerals are tranſlated, with conſiderable additions and alterations, from Vauquelin's paper, in the 30th volume of the Annales de Chimie.

I have now only to intreat the candid indulgence of the reader towards the errors and omiſſions which will doubtleſs be found in this work; and in apology for which, I have to allege, that on undertaking the publication, I had a proſpect of conſiderably more leiſure, than fell to my lot in the proſecution of it. This apology, I am under the neceſſity of prefixing, alſo, to this ſecond edition; the rapid ſale of the firſt having allowed me no time for material alterations, and having limited me to a few verbal corrections.

MANCHESTER,
June 26, 1801.

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AN

EPITOME

OF

CHEMISTRY,

IN

THREE PARTS.

EPITOME OF CHEMISTRY.

PART I.

SECTION I.

Advice to Perſons who are entering on the Study of Chemiſtry.

THE few ſuggeſtions which I am about to offer, are addreſſed peculiarly to thoſe who have not the opportunity of attending chemical lectures; and who have no means of acquiring a knowledge of chemiſtry, except from books, and from the evidence of experiments.

The principal difficulty, experienced by all, who embark in a ſcientific purſuit, unaided by the advice of an inſtructor, is the attainment of the beſt adapted books. In Chemiſtry, fortunately, this difficulty is limited to ſelection only: For we have, in the Engliſh language, many elementary works, both original and tranſlated, of great merit. I ſhall, at preſent, however, confine myſelf to the mention of very few; of ſuch only as are ſufficient to convey, to a perſon of tolerable underſtanding and competent education, a general acquaintance with chemical ſcience; and I ſhall afterward ſubjoin a liſt of other books, neceſſary to thoſe, who intend to purſue the ſtudy more extenſively.

Of all the introductory treatiſes on Chemiſtry, that of Mr. Lavoiſier is certainly the one, from which a perſon, entering, for the firſt time, on this ſtudy, will derive moſt *pleaſure* and advantage. The firſt part of this work, comprehending the more general doctrines of Chemiſtry, ſhould be peruſed with attention, and clearly underſtood, before the reader proceeds any further. It may even, be neceſſary, that, previouſly to the remainder of this work, he ſhould ſtudy other elementary books, ſuch as thoſe of Chaptal, Fourcroy, and Nicholſon. Theſe works will ſupply the deficiencies of Lavoiſier's Elements, eſpecially on the ſubject of chemical affinity, the diviſions and laws of which are eſſential to be known, as the ground work of all chemical explanations. After having made himſelf maſter of the more general truths of Chemiſtry, as delivered in the firſt part of Lavoiſier's, and in the firſt volume of Chaptal's Elements, and alſo of the principles of the New Nomenclature, the ſtudent will be qualified to reap advantage from the performance of experiments. In repeating theſe, he may either follow the order which I ſhall preſently point out; or he may aſſume, as the baſis of his arrangement, the general propoſitions laid down by Chaptal or Fourcroy; referring to the following Section, for more minute and ſpecific directions.

In the conducting of experiments, I would recommend great attention to Neatneſs and to Order. Let every jar or phial have a label fixed to it, denoting the ſubſtances it may contain, (except in caſes, where the nature of the contents is evident from mere inſpection) and the date and object of the experiment. I would caution the ſtudent, not to engage in many different experiments at once; the conſequences of which are, that the attention is diſtracted, and that many intereſting changes paſs unnoticed. It will contribute to form a habit of accurate obſervation, if the appearances, that occur in experiments, be regularly and diſtinctly noted down; and ſuch an exerciſe will tend, alſo, to facilitate the acquirement of the art of deſcribing chemical phenomena, to do which, with ſelection and preciſion, is far from being an univerſal talent.

In adviſing an attention to neatneſs, however, I am far from recommending a frivolous regard to ſhew, or even too ſcrupulous a nicety about the appearance of apparatus. With the aid merely of Florence flaſks, of common phials, and of wine-glaſſes, ſome of the moſt intereſting and uſeful experiments may be made; and in converting theſe veſſels to the purpoſe of apparatus, a conſiderable ſaving of expence will accrue to the experimentaliſt.*

SECTION II.

An arranged Series of Experiments, which ſhould, either wholly or in part, be performed by the Student of Chemiſtry.

IN the ſelection of theſe experiments, I ſhall generally chuſe ſuch as may be undertaken by perſons not poſſeſſed of an extenſive chemical apparatus. On ſome occaſions, however, it may be neceſſary, in order to complete the ſeries, that others ſhould be included, requiring, for their performance, inſtruments of conſiderable nicety. The ſame experiment may, perhaps, in a few inſtances, be repeatedly introduced, in illuſtration of different principles; but this repetition will be avoided as much as poſſible. Each experiment will be preceded by a brief enunciation of the general truth which it is intended to illuſtrate.

ART. 1. *Chemical Affinity, Solution, &c.*

For theſe experiments, a few wine glaſſes, or in preference, deep ale-glaſſes, will be required, and a Florence flaſk for performing the ſolutions.

1. *Some bodies have no affinity for each other.* Oil and water, or mercury and water, when ſhaken toge-

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* For a compleat œconomical Apparatus, that may be obtained for a few ſhillings, ſee Doctor WOODHOUSE's, annexed to the Philadelphia edition of Parkinſon's Chemical Pocket-book, publiſhed by the Printer hereof, and which may be had of him.

ther, do not combine, the oil or water always riſing to the ſurface, and the mercury ſinking to the bottom.

2. *Examples of Solution.* Sugar, or common ſalt, in water; chalk in dilute muriatic acid.*

3. *Influence of mechanical diviſion in promoting the action of chemical affinity, or in favouring ſolution.* Lumps of chalk or marble diſſolve much more ſlowly in dilute muriatic acid, than equal weights of the ſame bodies in powder. In the common arts of life, the raſping or grinding of wood, and other ſubſtances, are familiar examples.

4. *Hot liquids are more powerful ſolvents than cold ones.* To four ounces meaſure of water, at the temperature of the atmoſphere, add three ounces of ſulphate of ſoda in powder. Only part of the ſalt will be diſſolved, even after being agitated ſome time. Apply heat; and the whole of the ſalt will diſappear. When the liquor cools, a portion of ſalt will ſeparate again in a regular form. This laſt appearance affords an inſtance of *chryſtallization.*

5. *A very minute diviſion of bodies is effected by ſolution.* Diſſolve two grains of ſulphate of iron in a quart of water, and add a few drops of this ſolution to a wine-glaſs full of water, into which a few drops of tincture of galls have been fallen. The dilute infuſion of galls will ſpeedily aſſume a purpliſh hue. This ſhews that every drop of the quart of water in which the ſulphate of iron was diſſolved, contains a notable portion of the ſalt.

6. *Some bodies diſſolve much more readily and copiouſly than others.* Thus an ounce meaſure of diſtilled water will diſſolve one third its weight of ſulphate of ſoda; one ſixteenth of ſulphate of pot-aſh; and only one five hundredth its weight of ſulphate of lime.

7. *Mechanical agitation facilitates ſolution.* Into a wine-glaſs full of water, tinged blue with the infuſion

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* I omit purpoſely, the diſtinction between ſolution and diſſolution.

of litmus, let fall a ſmall lump of ſolid tartarous acid. The acid, if left at reſt, even during ſome hours, will only change to red that portion of the infuſion, which is in immediate contact with it. Stir the liquor, and the whole will immediately become red.

8. *Bodies do not act on each other, unleſs either one or both be in a ſtate of ſolution.* A. Mix ſome dry acid of tartar with dry carbonate of pot-aſh. No combination will enſue till water is added, which, acting the part of a ſolvent, promotes the union of the acid and alkali, as appears from the violent effervescence.

B. Spread thinly on a piece of tinfoil, three or four inches ſquare, ſome dry nitrate of copper,* and wrap it up. No effect will follow. Unfold the tinfoil, and having ſprinkled the nitrate of copper with very little water, wrap it up again as quickly as poſſible, preſſing down the edges cloſely. Conſiderable heat attended with fumes will now be excited; and if the experiment has been dexterouſly managed, even light will be evolved. This ſhews that nitrate of copper has no action on tin, till in a ſtate of ſolution.

9. *Two bodies, having no affinity for each other, unite by the intervention of a third.* Thus, the oil and water, which, in experiment 1ſt, could not, by agitation, be brought into union, unite intimately on adding a little ſolution of cauſtic pot-aſh. The alcali, in this caſe, acts as an intermedium.

10. *Saturation illuſtrated.* Water, after having taken up as much common ſalt as it can diſſolve, is ſaid to be ſaturated with ſalt. Muriatic acid, when it has ceaſed to act any longer on lime, is ſaid to be ſaturated.

11. *The properties, characterizing bodies when ſeparate, are deſtroyed, by chemical combination,* Thus muriatic acid and lime, which, in a ſeparate ſtate, have

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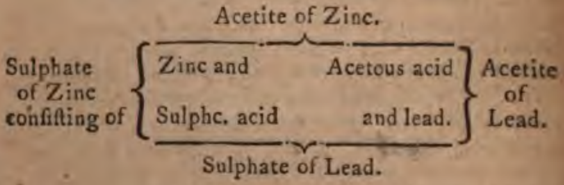
* To prepare nitrate of copper, diſſolve the filings or turnings of that metal in a mixture of one part nitrous acid, and three parts water; decant the liquor, when it has ceaſed to emit fumes; and evaporate it to dryneſs in a copper or earthen diſh. The dry maſs muſt be kept in a bottle.

each a moſt corroſive taſte, loſe this entirely, when mutually ſaturated; the compound is extremely ſoluble, though lime itſelf is very difficult of ſolution; the acid no longer reddens ſyrup of violets; nor does the lime change it, as before, to green.

12. *Simple elective affinity illuſtrated.* (A) Add to the combination of oil with alcali, formed in expt. 9th, a little dilute ſulphuric acid. The acid will ſeize the alcali, and ſet the oil at liberty, which will riſe to the top. In this inſtance, the affinity of alcali for acid is greater than that of alcali for oil. (B) To a dilute ſolution of muriate of lime, (prepared in expt. 2d.) add a little of the ſolution of pure pot-aſh. The pot-aſh will ſeize the muriatic acid, and the lime will fall down, or be *precipitated*.

13. *Double elective affinity exemplified.* In a watery ſolution of ſulphate of zinc, immerſe a thin ſheet of lead. The lead will remain unaltered, as will, alſo, the ſulphate of zinc; becauſe zinc attracts ſulphuric acid more ſtrongly than lead. But let acetite of lead be mixed with ſulphate of zinc, the lead will then go over to the ſulphuric acid, while the zinc paſſes to the acetous. The ſulphate of lead, being inſoluble, will fall down in the ſtate of a white powder; but the acetite of zinc will remain in ſolution. The changes that occur in this experiment, will be better underſtood from the following ſcheme.



For an explanation of theſe diagrams, which the ſtudent will find it highly uſeful to underſtand, I refer to Bergman's Treatiſe on Elective Attractions.

ART. II. *Properties and Effects of the Matter of Heat, or Caloric.*[*]

Effects of Caloric of Temperature, or uncombined Caloric.

1. *Caloric expands all bodies.* (A) The expanſion of liquids is ſhown by that of the mercury of a thermometer. (B) That of aëriform bodies, by holding near the fire, a bladder partly filled with air, the neck of which is cloſely tied, ſo as to prevent the encloſed air from eſcaping. The bladder will ſoon be fully diſtended, and may even be burſt by continuing and encreaſing the heat. (C) The expanſion of ſolids is ſhewn, by heating a rod of iron, of ſuch a length as to be included, when cold, between two points, and the diameter of which is ſuch, as to allow it to paſs through an iron ring. When heated, it will have become ſenſibly longer; and will be found incapable of paſſing through the ring.

All the above bodies return again, on cooling, to their former dimenſions.

2. *Conſtruction of the Thermometer founded on the principle of expanſion.* For an excellent account of the method of conſtructing thermometers, which is too long to be inſerted in this place, ſee Nicholſon's Principles of Chemiſtry, book 1ſt, chapter 3d.

3. *Equal increments or decrements of heat produce equal increments or decrements of expanſion in the mercury of the thermometer.* Mix a pound of water, at 172°, with a pound at 32°. Half the exceſs of the uncombined Caloric, in the hot water, will paſs to the colder portion; that is, the hot water will be cooled 70°, and the cold

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[*] I omit giving a connected ſeries of experiments on Light, becauſe the effects produced by this agent, are, generally ſpeaking, more complicated than thoſe of Caloric. Thus, for example, the action of light frequently depends on its property of deoxidating bodies; and facts of this kind cannot be underſtood, without an acquaintance with the claſs of metallic oxyds. In the progreſs of this ſection, however, many inſtances will be given of the chemical efficiency of Light.

will receive 70° of temperature; therefore, 172—70, or 32+70,=102, will give the heat of the mixture. To attain the arithmetical mean, exactly, ſeveral precautions, however, muſt be obſerved. (See Crawford on Animal Heat, p. 95, &c.)

4. *Uncombined Caloric has a tendency to an equilibrium.* Any number of different bodies, at various temperatures, if placed under ſimilar circumſtances of expoſure, all acquire a common temperature. Thus, if in an atmoſphere at 60°, we place iron filings heated to redneſs; boiling water; and various other bodies of different temperatures, they will ſoon affect the thermometer in the ſame degree.

5. *Power inherent in bodies of conducting Caloric; and the conducting power various in different bodies.*

(A) Solid bodies convey heat in all directions, upwards, downwards, and laterally; as may be ſhewn by heating one end of an iron rod, and holding it in different directions.

(B) Some bodies conduct caloric much more quickly than others. Coat two rods, of equal length and thickneſs, the one of glaſs, the other of iron, with wax, at one end of each only; and then apply heat to the uncoated ends. The wax will be melted much ſooner from the end of the iron rod, than from the glaſs one; which ſhows, that iron conducts heat more quickly than glaſs.

C. Liquid and aeriform bodies convey heat on a different principle, from that, obſerved in ſolids, viz. by an actual change in the ſituation of their particles. Take a glaſs tube eight or ten inches long, and about an inch in diameter. Pour into the bottom part, for about the depth of an inch, a little water tinged with litmus, and then fill up the tube with common water, pouring on the latter extremely gently, ſo as to keep the two ſtrata quite diſtinct. When the tube is heated at the bottom, the cold infuſion will aſcend, and will tinge the whole maſs. But if the upper part of the tube be heated, the coloured liquor will remain at the bottom. Other experiments, illuſtrating the ſame principle, may be found in Count Rumford's Eſſays, eſpecially, in Eſſay 7th. Thus a cake of ice will remain unmelted, during ſeveral hours, when confined at the bottom of a jar of hot water, which, if fixed at the ſurface, would be liquified in a few minutes; and water may even be kept boiling, a conſiderable time, in a glaſs tube, over ice, without melting it.

5 *The boiling point differs in various liquors.* Thus Ether boils at 104°, Alchohol at 182°, and water at 212°. It varies, alſo, in the ſame liquor, under different degrees of atmoſpheric preſſure. Thus water will boil, under the exhauſted receiver of an air pump, at 180°, or even much leſs, of Faht. Hence the particles of Caloric are mutually repulſive, and they communicate this repulſive tendency to other bodies in which Caloric is contained. This repulſive power tends to change ſolids into fluids, and liquids into aeriform bodies, and is chiefly counteracted by the preſſure of the atmoſphere. See ſome beautiful experiments illuſtrating this poſition in Lavoiſier's Elements, chap. 1.

On the contrary, by conſiderably increaſing the preſſure, water may be heated to above 400°,* without being changed into vapour.

6 *Uncombined Caloric promotes the action of chemical affinity.* Thus lead and tin do not combine, till melted together. In other inſtances, Caloric ſerves as the mean of ſeparating bodies already united. Thus lead and ſulphur are diſunited, by expoſure in a high temperature. In favouring the operation of affinity, Caloric ſeems to act as a ſolvent; and in decompoſing bodies, its effects are perhaps explicable on the principle of elective affinity. Thus, in the foregoing example, ſulphur, in a high temperature, or when ſurrounded by a great quantity of uncombined caloric, is more powerfully attracted by caloric than by lead.

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* To effect this, a ſtrong iron veſſel, called a Digeſter, is neceſſary.

7. *The ſenſible heat, or temperature, of ice, not changed by liquefaction.* A thermomether in pounded ice ſtands at 32°, and at the very ſame point in the water, which reſults from the liquefaction of ice.

8. *Yet the ice, during liquefaction, muſt abſorb much caloric.* Expoſe a pound of water at 32°; and a pound of ice at 32°, in a room, the temperature of which is above the freezing point, and uniformly the ſame during the experiment. The water will arrive at the temperature of the room, ſeveral hours before the ice is melted. Yet the ice muſt, during the whole of this time, be receiving caloric, becauſe, according to expt. 4, a hotter body can never be in contact with a colder one, without imparting heat to the latter. The Caloric therefore, which has entered the ice, but is not to be found in it by the thermometer, muſt be chemically combined; juſt as muriatic acid, by union with lime, loſes all its characteriſtic properties.

9. *The quantity of uncombined, caloric, that enters into a pound of ice, and becomes united, during liquefaction, may be learned by experiment.* To a pound of water, at 172°, add a pound of ice at 32°. The temperature will not be the arithmetical mean, as in expt. 6, but much below it, viz. 32°. From 102°, therefore, the arithmetical mean, take 32°; the remainder, 70°, ſhows the quantity of caloric, that combines with a pound of ice, during liquefaction; that is, as much caloric is abſorbed by, and unites chemically with, a pound of ice during its converſion into water, as would raiſe a pound of water from 32° to 102°.

9. *Other examples of the abſorption of caloric, during the liquefaction of bodies,* are furniſhed by the mixture of ſnow and nitric acid; or of ſnow and common ſalt, both of which, in common language, produce intenſe cold*. Moſt neutral ſalts, alſo, during ſolution in

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* The extraordinary powers of muriate of lime and ſnow in generating cold, will be deſcribed hereafter.

water, abſorb much caloric, and the cold thus generated is ſo intenſe as to freeze water and even to congeal mercury. The former experiment, however, may eaſily be repeated. Add to 32 drachms of water, 11 drachms of muriate of ammonia; 10 of nitrate of pot-aſh; and 16 of ſulphate of ſoda; all finely powdered. The ſalts may be diſſolved, ſeparately, in the order ſet down. A thermometer, put into the ſolution, will ſhow that the cold produced is at or below freezing; and a little water, in a thin glaſs tube, being immerſed in the ſolution, will be frozen in a few minutes. Various other freezing mixtures are deſcribed in Mr. Walker's papers in the Philoſophical Tranſactions for 1787, 88, 89, & 95.

10. *On the contrary, liquids, in becoming ſolid, evolve or give out caloric, or in common language, produce heat.*

(A.) Water, if kept perfectly free from agitation, may be cooled down below 32°; but, on ſhaking, it immediately congeals, and the temperature riſes to 32°.

B. To a ſaturated ſolution of ſulphate of pot-aſh in water, or of any ſalt that is inſoluble in alcohol, add an equal meaſure of alcohol. The alcohol, attracting the water more ſtrongly than the ſalt, retains it, precipitates the ſalt, and conſiderable heat is produced.

Caloric the cauſe of Vapour.

11. *Steam has exactly the ſame temperature as boiling water.* Let a tin veſſel be provided, having a hole in its cover, juſt large enough to admit a thermometer. Fill it partly with water, and let the bulb of the thermometer be an inch or two above the ſurface of the water. When the water boils, the thermometer, ſurrounded by ſteam, will riſe to 212°, which is preciſely the temperature of the water beneath. Yet water, placed on a fire, continues to receive heat, very abundantly, even when boiling hot; and as this heat is not appreciable by the thermometer, it muſt be in a ſtate of chemical union.

12. *The abſorption of caloric, during evaporation, ſhewn by experiment.*

Moiſten a thermometer with alcohol, or with ether, and expoſe it to the air, repeating theſe operations alternately. The mercury of the thermometer will ſink at each expoſure, becauſe the volatile liquor, during evaporation, robs it of its heat. In this way, (eſpecially with the aid of an apparatus, deſcribed by Mr. Cavallo in the Phil. Trans. for 1781, p. 509) water may be frozen in a thin and ſmall glaſs ball, by means of ether; and alſo by immerſing a tube, containing water at the bottom, in a glaſs of ether, placed under the receiver of an air-pump. During the exhauſtion of the veſſel, the ether will evaporate rapidly; and, robbing the water of heat, will completely freeze it.

13. *On the contrary, vapours during their converſion into a liquid form, evolve, or give out, much caloric.* The heat given out, by the condenſation of ſteam, is rendered apparent by the following experiment. Mix 100 gallons of water, at 50°, with one gallon of water at 212°*. The temperature of the water will be raiſed about 1½ degree. Condenſe, by a common ſtill-tub, one gallon of water from the ſtate of ſteam, by 100 gallons of water at the temperature of 50°. The water will be raiſed 11 degrees. Hence, eight pounds of water, condenſed from ſteam, raiſe 100 gallons of cold water, 9½ degrees more than eight pounds of boiling water; and by an eaſy calculation, it appears, that the caloric imparted to the 100 gallons by the ſteam, if it could be condenſed in one gallon of water, would raiſe it to 950°. A pound of water, therefore, in the ſtate of ſteam, contains more caloric, than a pound of boiling water, in the proportion of 950 to 212.

ART. III. *Gaſſes in General.*

For performing the neceſſary experiments on gaſſes, many articles of apparatus are eſſential, that cannot be included in a portable chemical cheſt, which may yet however, contain the materials for procuring gaſſes. It may aſſiſt the ſtudent in obtaining the neceſſary inſtruments, if a few of the moſt eſſential be here enumerated. I ſhall mention none, however, except ſuch as are neceſſary in making a few general experiments on this intereſting claſs of bodies.

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* This experiment will be equally concluſive, if repeated on a ſmaller ſcale.

The apparatus, required for experiments on gaſſes, conſiſts partly of veſſels fitted for containing the materials that afford them; and partly of veſſels adapted for the reception of gaſſes, and for ſubmitting them to experiment.

1. For procuring ſuch gaſſes, as are producible without a very ſtrong heat, glaſs bottles, furniſhed with ground ſtoppers, and bent tubes, are ſufficient. Of theſe ſeveral will be required of different ſizes and ſhapes, adapted to different purpoſes. If theſe cannot be procured, a Florence flaſk with a cork perforated by a bent glaſs tube, will ſerve for obtaining ſome of the gaſſes.

Thoſe gaſſes, that require for their liberation a red heat, may be procured by expoſing to heat the ſubſtance, capable of affording them, in earthen retorts, or tubes*; or in a gun barrel, the touch-hole of which has been accurately cloſed by an iron pin. To the mouth of the barrel muſt be affixed a glaſs tube, bent ſo as to convey the gaſſes, wherever it may be requiſite.

2 For receiving the gaſſes, glaſs jars of various ſizes are required, ſome of which ſhould be furniſhed with necks at the top, fitted with ground ſtoppers. Theſe jars will, alſo, be found extremely uſeful in experiments on the properties and effects of the gaſſes.

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* Very compact earthen retorts and tubes are made by Meſſrs. Wedgwoods and Byerly, of Etruria. Others, alſo, leſs cloſe in their texture, but leſs apt to break in the fire, may be had of Meſſrs. Pugh and Speck, of Booth-ſtreet, Spital Fields, London, who make portable furnaces, crucibles, &c.

Some of them ſhould be graduated into cubical inches.

To contain theſe jars, when in uſe, a veſſel will be neceſſary, capable of holding a few gallons of water. This may either be of wood, if of conſiderable ſize; or, if ſmall, of tin japanned or painted. Its ſize may vary with that of the jars employed; and about an inch and an half from the top it ſhould have a ſhelf, on which the jars may be placed, when filled with air, without the riſk of their being overſet.

A glaſs tube, about 18 inches long, and 3 quarters of an inch diameter, cloſed at one end, and divided into cubic inches and tenths of inches, will be required for aſcertaining the purity of air. It ſhould be accompanied, alſo, with a ſmall meaſure, containing about two cubic inches, and similarly graduated. Besides theſe, the experimenter ſhould be furniſhed with air funnels, for transferring gaſſes from wide to narrow veſſels. These, and almoſt every other article of apparatus, neceſſary for experiments on gaſſes, may be ſeen figured in the plates to Doctor Prieſtley's Experiments on Air, in 3 vols. 8vo. and in thoſe ſubjoined to Lavoiſier's Elements.

For thoſe gaſſes, that are abſorbed by water, a mercurial trough is neceſſary. For the mere exhibition of a few experiments on theſe condenſible gaſſes, a ſmall wooden trough, 11 inches long, 2 wide, and 2 deep, cut out of a ſolid block of mahogany, is ſufficient; but for experiments of reſearch, one of conſiderable ſize is required.

Previouſly to undertaking experiments on other gaſſes, it may be well for an unpractiſed experimentaliſt to accuſtom himſelf to the dexterous management of gaſſes, by transferring common air from one veſſel to another of different ſizes.

Of experiments illuſtrative of the nature of gaſſes in general, it may be proper to mention one or two, that ſhew the mode in which caloric exiſts in this claſs of bodies. In vapours, ſtrictly ſo called, as the ſteam of water, caloric ſeems to be retained with but little force, for it quits the water, when the vapour is merely expoſed to a lower temperature. But in gaſſes, caloric is united by very forcible affinity, and no diminution of temperature, that has ever yet been effected, can ſeparate it from ſome of them. Thus the air of our atmoſphere, in the moſt intenſe artificial or natural cold, ſtill remains in the aeriform ſtate. Hence is derived one character of gaſſes, viz. that they ſhall remain aeriform, under almoſt all variations of preſſure and temperature; and in this claſs are, alſo included, thoſe aerial bodies, which being condenſed by water, require confinement over mercury. The following experiment will ſhow that the caloric, contained in gaſſes, is chemically combined.

Into a ſmall retort, put an ounce or two of common ſalt, and about half its weight of ſulphuric acid. By this proceſs, a great quantity of gas is produced, which might be received and collected over mercury. But to ſerve the purpoſe of this experiment, let it paſs through a glaſs balloon, having two openings (as in the 4th plate of Lavoiſier. fig. 1, G.), into one of which the neck of the retort paſſes, while, from the other, a bent tube proceeds (E. of the ſame fig.) which ends in a veſſel of water. Before cloſing the apparatus, let a thermometer be included in the balloon to ſhew the temperature of the gas. It will be found, that the mercury, in this thermometer, will riſe only a few degrees, whereas the water, in the veſſel which receives the bent tube, will ſoon become boiling hot. In this inſtance, caloric flows from the lamp to the muriatic acid, and converts it into gas; but the heat, thus expended, is not appreciable by the thermometer, and muſt, therefore, be chemically combined. The caloric, however, is again evolved, when the gas is condenſed by water, and in this experiment, we trace it into combination, and again into the ſtate of uncombined caloric.

For demonſtrating the influence of variations of atmoſpheric preſſure on the formation of gaſſes, better experiments cannot be deviſed than thoſe of Lavoiſier. See his Elements, chap. 1. But as ſome ſtudents, who have the uſe of an air pump, may not poſſeſs the apparatus deſcribed by Lavoiſier, (the glaſs bell and ſliding wire), it may be proper to point out an eaſier mode of ſhewing the ſame fact. Into a glaſs tube about ſix inches long, and half an inch diameter, ſealed at one end, put a ſmall quantity of ether; and fill the tube with water, tinged blue by litmus. The ether will ſwim on the ſurface of the water. Place the thumb, expeditiouſly, over the open end of the tube, ſo as to confine the water and ether without including any air along with them; and ſet the tube, inverted in a jar of coloured water; removing the thumb, when this has been effected. When the above apparatus is covered with the receiver of an air pump, and the air is exhauſted, the ether will be changed into a gas, which will fill the tube, and expel the water. On reſtoring the preſſure of the atmoſphere, the ether will again become liquid.

ART. IV. *Oxygenous Gas.*

1. *Oxygenous gas may be procured from various ſubſtances.*

A. From oxyd of manganeſe, heated to redneſs in a gun barrel, or earthen retort; or from the ſame oxyd, heated by a lamp in a retort or gas bottle, with half its weight of ſtrong ſulphuric acid.

B. From the red oxyd of lead (the common red lead uſed by painters) heated either with or without ſulphuric acid.

C. From various other oxyds, as will be hereafter mentioned.

D. From nitrate of pot-aſh (common ſalt-petre) made red hot in a gun barrel, or in an earthen retort.

E. From oxygenated muriate of pot-aſh, heated in a ſmall glaſs retort, coated with clay; or in an earthen retort. The oxygenous gas thus produced is much purer than that obtained in any other mode, eſpecially the laſt portions, which ſhould be kept ſeparate.

This Gas has the following properties:

2. *It is not abſorbed by water*, or at leaſt is ſo ſparingly abſorbed, that when agitated in contact with water, no perceptible diminution takes place.

3. *All combuſtible bodies burn in oxygenous gas with greatly increaſed ſplendor.*

(A.) A lighted wax taper, fixed to an iron wire, and let down into a veſſel of gas, burns with great brilliancy, (See Lavoiſier's 5th plate, fig. 8.) If the taper be blown out, and let down into a veſſel of the gas, while the ſnuff remains red hot, it inſtantly rekindles, with a ſlight exploſion.

B. A red hot bit of charcoal, faſtened to an iron wire, and immerſed in the gas, throws out beautiful ſparks.

C. The light of phoſphorous, placed on a little tin cup, and burnt in this gas, is the brighteſt that can be in any mode produced.

D. Procure ſome thin harpſicord wire, and twiſt it round a ſlender rod of iron or glaſs, ſo as to coil it up in a ſpiral form. Then withdraw the rod, and tie a little thread round one end of the wire, for about the length of one-twentieth of an inch, which end is to be dipped into melted ſulphur. The other end of the wire is to be fixed into a cork; ſo that the ſpiral may hang vertically. Fill, alſo, with oxygenous gas, a bottle capable of holding about a quart, and ſet it with its mouth upwards. Then light the ſulphur, and introduce the wire into the bottle of gas, ſuſpending it by the cork. The iron will burn with a moſt brilliant light, throwing out a number of ſparks, which fall to the bottom of the bottle, and generally break it. This accident, however, may frequently, be prevented by pouring ſand into the bottle, ſo as to lie about half an inch deep on the bottom. (See Lavoiſier's 4th plate, fig. 17.)

E. A little of Homberg's pyrophorous, a ſubſtance to be hereafter deſcribed, when poured into this gas, immediately flaſhes like inflamed gun-powder.

4. *During every combuſtion in oxygenous gas, the gas ſuffers a material diminution.* To exhibit this experimentally, in a manner perfectly free from all ſources of error, would require ſuch an apparatus as few perſons are likely to poſſeſs. The apparatus required, may be ſeen deſcribed in the 6th chapter of Lavoiſier's Elements. The fact may, however, be ſhown leſs accurately, in the following manner. Fill with oxygenous gas, a jar of moderate ſize, which has a neck and ground glaſs ſtopper at the top. Then, with the aſſiſtance of a ſtand, formed of bent iron wire, (like that ſhewn in the plate to Nicholſon's Chemiſtry, fig. 16,) place a ſhallow tin veſſel, containing a bit of phoſphorus or ſulphur, three or four inches above the level of the water of a pneumatic trough. Invert the jar of oxygenous gas, cautiouſly and expeditiouſly, over this cup, ſo as to confine it with its contents in the gas, and preſſing down the jar to the bottom of the trough, open the ſtopper. A quantity of gas will immediately ruſh out, and the water will riſe to the ſame level within the jar as without. When this has taken place, ſet fire to the ſulphur or phoſphorus by an iron wire, and inſtantly put in the ſtopper. The firſt effect of the combuſtion will be a depreſſion of the water within the jar; but when the combuſtion has cloſed, and the veſſel has cooled, a conſiderable abſorption will be found to have enſued.

5. *All bodies, by combuſtion in oxygenous gas, acquire an addition to their weight; and the increaſe is in proportion to the quantity of gas abſorbed.* To prove this by

experiment, requires, alſo, a complicated apparatus; and the reader, who cannot poſſeſs himſelf of this, muſt remain ſatisfied with the account given by Lavoiſier of his experiments, eſtabliſhing the principle, in chapter 5th of his Elements.

6. *Oxygenous gas ſupports, eminently, animal life.* It will be found that a mouſe, bird, or other ſmall animal, will live ſix times longer in a veſſel of oxygenous gas, than in one of atmoſpherical air of the ſame dimenſions.

7. *This effect ſeems connected with the abſorption of oxygen by the blood.* Paſs up a little dark coloured blood into a jar partly filled with oxygen gas, and ſtanding over mercury. The gas will in part be abſorbed, and the colour of the blood will be changed to a bright and florid red. This change to red may be ſhewn by putting a little blood into a common phial filled with oxygenous gas, and ſhaking it up.

ART. V. *Azotic or Nitrogen Gas.*

1. Azotic Gas may be procured, though not abſolutely pure, yet ſufficiently ſo for the purpoſe of exhibiting its general properties, in the following manner. Mix equal weights of iron filings and ſulphur into a paſte with water, and place the mixture in a proper veſſel, over water, on a ſtand ſimilar to that deſcribed, Art. IV. No. 4. Then invert over it a jar full of common air, and allow this to ſtand expoſed to the mixture for a day or two. The air, contained in the jar, will gradually diminiſh, as will appear from the aſcent of the water within the jar, till at laſt, only about three-fourths remain of its original bulk. The veſſel, containing the iron and ſulphur, muſt next be removed, by withdrawing it through the water; and the remaining air may be made the ſubject of experiment.

2. This gas has the following properties:

A. It is not abſorbed by water.

B. It immediately extinguiſhes a lighted candle, and all other burning ſubſtances.

C. It is fatal to animals that are confined in it.

D. Plants, however, live in it, and even flouriſh.

E. When mixed with pure oxygenous gas, in the proportion of one part to three of the latter, it compoſes a mixture, reſembling atmoſpheric air in all its properties. Of this any one may be ſatisfied, by mixing three parts of azotic gas with one of oxygenous gas; and immerſing in the mixture a lighted taper. The taper will burn as in atmoſpherical air.

ART. VI. *Atmoſpheric Air.*

The Air of our atmoſphere, it appears, therefore, from the foregoing facts, is a mixture, or rather a combination, of two different gaſſes, viz. oxygenous gas, and azotic gas. The former of theſe two ſeems to be the only ingredient on which the effects of the air, as a chemical agent, depend. Hence combuſtible bodies burn in atmoſpheric air, only in conſequence of the oxygenous gas, which it contains; and when this is exhauſted, air is no longer capable of ſupporting combuſtion[*]. The abſtraction, from the air, of its oxygenous gas, will be rendered apparent by the following experiments.

1. Burn a little ſulphur or phoſphorus, in the manner deſcribed, Art. IV. No. 4. ſubſtituting for oxygenous gas, common atmoſpherical air. The combuſtion will in this inſtance be leſs vivid; will ceaſe ſooner; and the abſorption, when the veſſels have cooled, will be much leſs conſiderable than in the former caſe.

2. Take two tubes, each a few inches long, cloſed at one end, and divided into aliquot parts. Fill the one with atmoſpherical air, the other with oxygenous gas, and invert them in two ſeparate cups filled with a ſolu-

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[*] Certain combuſtible bodies even ceaſe to burn in atmoſpheric air, long before its oxygenous portion is conſumed; for reaſons that will hereafter be given.

tion of ſulphuret of pot-aſh. The ſulphuret will aſcend gradually within the tube of common air, till, after a few days, only about three-fourths of its original volume remain: But in that containing oxygenous gas, it will aſcend much higher; and if the gas be pure, will even abſorb the whole. The explanation of this fact is, that liquid ſulphuret of pot-aſh has the property of abſorbing oxygen, but not azote. It, therefore, acts in atmoſpheric air, only as long as any oxygenous gas remains; and may be employed as a means of aſcertaining the quantity of this gas in the atmoſphere at different times, and in diſtant places. An improved inſtrument, thus graduated, has lately been employed by Guyton as an *Eudiometer**. (See Nicholſon's Philoſophical Journal, Vol. I. page 268; or Tilloch's Philoſophical Magazine, Vol. III. p. 191.)

3. *Atmoſpheric air miniſters to the ſupport of animal life, only in conſequence of the oxygenous gas which it contains.* Air, after having been received into the lungs, and again expired, is found to have loſt conſiderably of its oxygenous part, viz. 10 or 12 per cent. It proves fatal to animals, however, long before the whole of this purer portion is wholly exhauſted; and hence it appears, that a conſiderable proportion of oxygenous gas is even neceſſary to fit the air for ſupporting reſpiration. As the analyſis of expired air requires an acquaintance with another gas not hitherto deſcribed, viz. carbonic acid, its examination will be poſtponed to a future occaſion.

ART. VII. *Hydrogenous Gas.*

1. *To procure hydrogenous Gas*, let ſulphuric acid, previouſly diluted with five or ſix times its weight of water, be poured on iron filings, or on ſmall iron nails, in a gas bottle or ſmall retort. An effervеſcence will enſue, and the eſcaping gas may be collected in the uſual manner.

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* Other Eudiometers will be deſcribed hereafter.

This gas has the following properties:

2. *It remains permanent over water*, or is not abſorbed in any notable proportion.

3. *It is inflammable*. This may be ſhewn by the following experiments.

A. Fill a ſmall jar with the gas, and holding it with the mouth downwards, bring the gas into contact with the flame of a candle. The air will take fire, and will burn ſilently with a lambent flame.

B. Fill with this gas, a bladder which is furniſhed with a ſtop cork, and with a ſmall pipe, of diameter leſs than that of a common tobacco pipe. Preſs the air out through the pipe, and on preſenting a lighted candle the ſtream will take fire. If this apparatus cannot be procured, a very ſimple contrivance will anſwer the purpoſe. Break off part of an eight ounce phial, within an inch or two from the bottom, by ſetting fire to a ſtring tied round it, and moiſtened with ſpirit of turpentine. The phial will then reſemble a jar with an open neck at the top. Next bore a ſmall hole through a cork that fits the neck of a phial, and inſert in it part of a common tobacco pipe, which may be fixed into the neck of the bottle, by a cement of reſin and bees-wax. Then fill the bottle with water, and hold it with the thumb preſſed down on the aperture of the pipe, while hydrogenous gas is paſſed into it. When the bottle is full of gas, remove thethumb, preſs the bottle down into the water, and on the approach of a candle the ſtream of air from the pipe will take fire. I prefer this mode of making the experiment to the common one of inflaming the gas as it proceeds, through a ſmall tube, from the bottle in which it is produced; becauſe I have once ſeen an exploſion, and frequently heard of ſimilar accidents, from the latter mode of making the experiment.

C. In a ſtrong bottle, capable of holding about four ounces of water, mix equal parts of common air and hydrogenous gas. On applying a lighted candle, the mixture will burn, not ſilently as in experiment A, but with a ſudden and loud exploſion. If a larger bottle be uſed, it ſhould be wrapped round with a handkerchief, to prevent the glaſs from doing any injury, in caſe the bottle ſhould burſt.

D. The ſame experiment may be repeated with oxygenous gas, inſtead of atmoſpherical air; changing the proportions, and mixing only one part of oxygenous gas, with two of hydrogenous: The report will be conſiderably louder. The bottle ſhould be a very ſtrong one, and ſhould be wrapped round with cloth, to prevent an accident.*

E The ſame experiment may be made over water, by means of the electric ſpark. Procure a ſtrong tube about three quarters of an inch diameter, and twelve inches long, cloſed at one end. About a quarter or half an inch from the ſealed end, let two ſmall holes be drilled, oppoſite to each other, and into each of theſe let a braſs conductor be cemented, ſo that the two points may be diſtant from each other, within the tube, about one eighth of an inch. Into this tube ſtanding over water, paſs about a cubic inch or leſs, of a mixture of hydrogenous and oxygenous gaſſes, in the proportion of two meaſures of the former to one of the latter. Hold the tube firmly, and paſs an electric ſpark through the mixed gaſſes. An immediate exploſion will take place; after which the gaſſes, if pure, and in the proper proportion, will be found to have diſappeared entirely. If atmoſpheric air be uſed, the remaining gas will be found to be unfit for ſupporting combuſtion, the hydrogenous gas having robbed it of all its oxygen. Hence, the inflammation of hydrogenous gas, in graduated tubes, has been employed as a means of meaſuring the purity of air, and is the principle of Volta's eudiometer.

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* Theſe experiments may, alſo, be made advantageouſly, by means of an apparatus, ſold under the name of the inflammable air piſtol.

F. The diminution of hydrogenous and oxygenous gaſſes, by the union of their baſes, may be ſhewn, alſo, by their ſlow combuſtion. Fill a tall jar with oxygenous gas; and fill also, with hydrogĕn gas, a bladder furniſhed with a ſtop cock, and with a long braſs pipe, bent like the letter S, and drawn out to a fine point. On preſſing the bladder, a ſtream of gas will iſſue from the pipe, which may be ſet fire to, and brought cautiouſly under the tall inverted jar of oxygenous gas. By this contrivance, the ſtream of hydrogen gas will be burnt in a confined portion of oxygen gas; and on continuing the combuſtion a ſufficient length of time, the water will be ſeen to rise gradually within the jar. On the firſt impreſſion of the heat indeed a quantity of gas will eſcape from the jar, which will render it difficult to aſcertain what degree of abſorption has actually taken place. But this loſs may be prevented by uſing a jar with a neck at the top, to which a compreſſed bladder is firmly tied. The expanded air, inſtead of eſcaping through the water, will now fill the bladder at the top; and when the experiment has cloſed, and the veſſels have cooled, it may be aſcertained, by preſſing out the gas from the bladder, what quantity of oxygen gas has been conſumed.

When the above experiment is made, with the ſubſtitution of common air for oxygenous gas, a diminution takes place, but much leſs conſiderable; viz. not amounting to one-ſixth the original bulk of the gas.

4. *Hydrogenous gas has an unpleaſant ſmell.*

5. *Though inflammable itſelf, it extinguiſhes burning bodies.* Bring an inverted jar, filled with this gas, over the flame of a candle; and depreſs the jar, ſo that the lighted wick may be wholly ſurrounded by the gas. The candle will immediately be extinguiſhed.

6. *It is fatal to animals.* This may be ſhewn by confining, in the gas, a mouſe, or other ſmall animal.

7. *It is conſiderably lighter than atmoſpherical air.*

A. Let a jar, filled with this gas, ſtand for a few ſeconds, with its open mouth upwards. On letting down a candle, the gas will be found to have eſcaped.

B. Place another jar of the gas inverted, or with its mouth downwards. The gas will now be found to remain in the jar, being prevented from eſcaping upwards by the bottom and ſides of the veſſel.

C. Fill with hydrogen gas, a bladder furniſhed with a ſtop cock; and adapt to this a common tobacco pipe. Dip the bowl of the pipe into a lather of ſoap, and turning the cock blow up the lather into bubbles. Theſe bubbles, inſtead of falling to the ground, like thoſe commonly blown by children, will riſe rapidly into the air. On this property of hydrogen gas, is founded its application to the raiſing of balloons.

8. *Hydrogenous gas, though fatal to animal life, is not ſo to vegetables, which grow and even flouriſh in it.*

ART. VIII. *Compoſition and Decompoſition of Water.*

In Art. VII. (No. 3. E.) it was ſtated that oxygenous and hydrogenous gaſſes, when fired over water, in the proper proportion, wholly diſappear. To aſcertain the nature of the product thus formed, however, the experiment muſt be repeated over mercury, in a ſimilar manner. When this is done repeatedly, it is found that the product of the combuſtion is that well known fluid water, which is thus proved to be compoſed of two elementary ingredients. The water, produced in this mode, is not, however, to be conſidered as a compound of the two gaſſes, but only of their baſes; for the light and caloric, which conſtituted the gaſſes, eſcape in conſiderable part, during the combuſtion. Every gas, it muſt be remembered, has at leaſt two ingredients; the one gravitating matter, which if ſeparate, would probably exiſt in a ſolid or liquid form; the other an extremely ſubtile fluid, termed caloric. In the example before us, caloric (and perhaps light) is a common ingredient both of hydrogen and oxygen gaſſes; but the two differ in having different baſes. The baſes of the one is called hydrogen, of the other oxygen; and water may, therefore, be affirmed to be a compound of hydrogen and oxygen. This may be proved in two modes, by ſyntheſis, i. e. by joining together its two elementary ingredients; and by analyſis, in other words, by ſeparating the conſtituent parts of water, and again exhibiting them in a diſtinct form.

1, *Synthetic Experiments.*

A. Fill, with hydrogen gas, a bladder, furniſhed with a ſtop-cock and bent pipe, ſimilar to that deſcribed, Art. VII. No. 3, F. Then pour into a ſhallow earthen diſh as much quickſilver as will about half fill it, and invert over this a glaſs bell full of common air and perfectly dry. Expel the hydrogen gas through the pipe; light the ſtream; and bring it under the glaſs bell, by raiſing this, and depreſſing it into the mercury, as ſoon as the inflamed gas is introduced. A portion of air will eſcape at firſt, in conſequence of the rarefaction. As the combuſtion continues, water will form, and will condenſe on the ſides of the glaſs. This water is produced by the union of hydrogen with the oxygen contained in atmoſpheric air.

B. Thoſe perſons, who are not poſſeſſed of a ſufficient quantity of quickſilver, to repeat the above experiment, may ſubſtitute the following. Procure a large glaſs globe, capable of holding three or four quarts, and having two openings, oppoſite to each other, which may be drawn out for a ſhort diſtance, like the neck of a retort. Inflame the ſtream of hydrogen gas, and introduce it into the centre of the globe. The rarefied and vitiated air will aſcend through the upper aperture of the globe, and a conſtant ſupply of freſh air will be furniſhed from beneath. By this combuſtion, a quantity of water will be generated, which will be condenſed on the inner ſurface of the veſſel.

C. A ſimple and ingenious apparatus, leſs coſtly than any other intended for the purpoſe of exhibiting the compoſition of water, is made by Mr. Cuthbertſon, of London. It may be ſeen deſcribed and figured in Nicholſon's Journal, Vol. II. p. 235; or in the Philoſophical Magazine, Vol. II. p. 317.

D. Thoſe perſons, who have the opportunity of repeating this intereſting experiment on a large ſcale, and with an accurate attention to proportion, may conſult Lavoiſier's Elements.

E. By firing repeated portions of a mixture of oxygenous and hydrogenous gaſſes, over mercury, a ſenſible quantity of water will at laſt be produced.

2. *Analytic Experiments.*

The analytic experiments on water are of two kinds, 1ſt. ſuch as preſent us with one of its ingredients only, in a ſeparate and diſtinct form; 2dly. ſuch as preſent us with its two component principles, the hydrogen and oxygen, mixed together in the ſtate of gas.

Of the firſt kind are the following:

A. Procure a gun barrel, the breech of which has been removed, ſo as to form a tube open at each end. Fill this with iron wire, coiled up in a ſpiral form. To one end of the barrel adapt a ſmall glaſs retort partly filled with water, and to the other a bent glaſs tube, the open end of which terminates under the ſhelf of the pneumato chemical apparatus. Let the barrel be placed horizontally, (or rather with that end, to which the retort is fixed, a little elevated) in a furnace, having two openings in its body oppoſite to each other, or in a grate like that figured by Lavoiſier plate 7, figure 11. Light a fire in the furnace; and when the gun barrel has become red hot, apply a lamp under the retort.

The ſteam of the water will paſs over the red hot iron, and will be decompoſed. Its oxygen will unite with the iron; and its hydrogen will be obtained in the form of a gas. This is the readieſt and cheapeſt mode of procuring hydrogen gas, when wanted in conſiderable quantity.

B. The ſame experiment may be repeated; ſubſtituting an earthen tube for a gun barrel, and weighing the iron wire, accurately, both before and after the experiment. The iron will be found to have gained weight very conſiderably; and if attention be paid to the weight of the water, that eſcapes decompoſition, by an addition to the apparatus, ſimilar to that employed by Lavoiſier, (plate 7. fig. 11. S and H) and to the weight of the gaſſes obtained, it will be found that the weight gained by the iron, added to that of the hydrogen gas, will make up exactly the weight of the water, that has diſappeared. From experiments of this kind, conducted with the utmoſt attention to accuracy, as well as from ſynthetic experiments, it appears that water is compounded of 85 per cent oxygen, and 15 hydrogen, by weight, very nearly. But as hydrogen gas is eleven times lighter than common air, the proportion of gaſſes, by volume, required to form water, is about two of hydrogen to one of oxygen gas.

C. Water may be decompoſed, in a ſimilar apparatus, over charcoal inſtead of iron. The reſults, however, are different in this caſe, as will appear from a ſubſequent ſection.

D. Another mode of effecting the decompoſition of water yet remains to be mentioned, in which not the hydrogen but the oxygen is obtained in a gaſeous ſtate. This is by the action of living vegetables; either entire, or by means of their leaves only. Fill a clear glaſs globe with water, and put into it a number of green leaves, from almoſt any tree or plant. A ſprig or two of mint will anſwer the purpoſe perfectly well. Invert the glaſs, and place it with its mouth downwards, in a veſſel of water. Expoſe the whole apparatus to the direct light of the ſun, which will then fall on the leaves, ſurrounded by water. Bubbles of air will ſoon begin to form on the leaves, and will increaſe in ſize, till at laſt they riſe to the top of the veſſel. This proceſs may be carried on, as long as the vegetable continues healthy; and the gas, when examined, will prove to be oxygenous gas nearly pure. In this experiment, the hydrogen combines with the plant, to the nouriſhment and ſupport of which it contributes, while the oxygen is ſet at liberty.

2dly. The proceſſes, by which the elementary parts of water are ſeparated from each other, and both are preſented in an aeriform ſtate, as a mixture of hydrogen and oxygen gaſſes, are dependent on the agency of electricity.

A. The firſt of theſe experiments requires, for its performance, the aid of a powerful electrical machine. This fact was the diſcovery of a ſociety of ingenious Dutch chemiſts; and the principal circumſtance, in the experiment, is the tranſmiſſion of electrical ſhocks, through a confined portion of water. The apparatus employed in this experiment of Meſſrs. Deimen and Van Trooſtwyk, is a glaſs tube, about one eighth of an inch diameter, and 12 inches long, one of the ends of which is ſealed hermetically, a gold wire being inſerted at this end, and projecting about an inch and an half within the tube. About the diſtance of five-eighths of an inch from the extremity of this, another wire is to be fixed, which may extend to the open end of the tube. The tube is next to be filled with diſtilled water, and to be placed inverted in a veſſel of the ſame. When thus diſpoſed, electrical ſhocks are to be paſſed, between the two ends of the wire, through the water; and if theſe ſhocks be ſufficiently ſtrong, bubbles of air will be formed at the exploſion, and will aſcend, till the upper part of the wire is uncovered by the water. As ſoon as this is effected, the next ſhock that is paſſed will ſet fire to the air; and the water will riſe again in the tube, a very ſmall quantity of gas remaining. Now as hydrogen and oxygen gaſſes, in a ſtate of admixture, are the only ones, that are capable of inflaming by the electric ſhock; and as there is nothing in the tube, beſides water, that can afford them in this experiment, we may ſafely infer, that the evolved hydrogen and oxygen gaſſes ariſe from decompoſed water.

B. An improved apparatus, exhibiting the ſame experiment with leſs trouble to the operator, has been invented by Mr. Cuthbertſon, and may be ſeen deſcribed and figured in Dr. Pearſon's paper, in the Phil. Trans. for 1797, or in Nicholſon's Journal, Vols. 1 and 2.

C. The ſame experiment may be performed with the aid of an apparatus of great ſimplicity, and which it is in the power of almoſt any perſon to make for himſelf. This is the newly diſcovered pile of Signior Volta; a diſcovery, which for curioſity, and importance in a philoſophical view, ranks with the firſt that have been made during the preſent century. It is conſtructed in the following manner.

Procure, at a brazier's or copper ſmith's, 30, 40, or 50 pieces of zinc or ſpeltre, caſt in ſand, of the ſize of half crowns or ſhillings, but rather thicker. A correſponding number of half crowns or ſhillings will, alſo, be required, according to the ſize of the pieces of zinc, that may be employed. Let an equal number of pieces of woollen cloth be cut of a circular ſhape, to correſpond with the pieces of zinc; and ſteep theſe in a ſtrong ſolution of common ſalt in water. Then diſpoſe the three ſubſtances, alternately, in the following order, ſilver, zinc, moiſtened cloth; ſilver, zinc, &c. till a ſufficient number of theſe triplicates, not leſs than 20 or 30, have been thus arranged, the ſilver terminating the pile at the top. In order to facilitate the touching of the bottom piece of ſilver, it may be well to put under it a ſlip of tinfoil or Dutch leaf, which may project a few inches. Next, let the hands be moiſtened with ſalt and water, and on touching the piece of tinfoil with one hand, and the uppermoſt piece of ſilver with the other, a ſhock will paſs through the arms, which will be ſtrong, in proportion to the number of pieces of zinc, &c. that are employed.

With this apparatus, the decompoſition of water is effected with the utmoſt facility. Take a narrow glaſs tube 3 or 4 inches long; fit each end with a cork, penetrated by a piece of ſlender iron wire, and fill the tube with water. Let the ends of the two wires be diſtant from each other, about three fourths of an inch; and let the one be made to communicate with the bottom of the pile, the other with the top. On making this communication, bubbles of air will form, and will aſcend to the top of the tube; the wire being rapidly oxydated. In this experiment, water is decompoſed: Its oxygen unites with the iron; while its hydrogen appears in the ſtate of gas.

If this experiment be made with the ſubſtitution, for iron, of ſome metal that is not oxydated by water, as gold for example, we obtain a mixture of hydrogen and oxygen gaſſes, as in the experiment of Meſſrs. Deimen and Van Trooſtwyk.

In Mr. Nicholſon's Journal, a variety of intereſting obſervations on the phenomena, produced by Volta's Galvanic Pile, have been publiſhed by Meſſrs. Nicholſon, Carliſle, Cruikſhank, Davy, and others.

ART. IX. *Properties and Effects of Water.*

1. *Water contains air.* This may be ſhewn by placing a glaſs veſſel of water under the receiver of an air pump. During the exhauſtion of the receiver, bubbles of air will be ſeen to aſcend very plentifully. Much air eſcapes alſo, from water, during ebullition, and may be collected by a proper apparatus.

2. *Water is contained in the air of the atmoſphere, even during the drieſt weather.* Expoſe to the air, in a ſhallow veſſel, a little carbonate of pot-aſh (not cryſtallized, but the common ſalt of tartar.) In a few days, it will have become moiſt, or *deliquiated.* On the ſame principle, water, expoſed to the air in a ſhallow veſſel, diſappears, being diſſolved by the atmoſphere.

3. *Water diſſolves a great variety of ſolid bodies.* The ſubſtances, on which it exerts this effect, are ſaid to be ſoluble in water; and there are various degrees of ſolubility, ſee Art. 1. No. 6.

4. *During the ſolution of bodies in water, a change of temperature enſues* In moſt inſtances, an abſorption of caloric, (in other words, a production of cold) is attendant on ſolution, as in the examples given in Art. 11, No. 9. But, in other caſes, caloric is evolved, or heat produced. Thus common ſalt of tartar, during ſolution in water, raiſes the temperature of its ſolvent; and cauſtic pot-aſh, in a ſtate of dryneſs, does the ſame ſtill more remarkably. Both carbonated and pure pot-aſh, however, when cryſtallized, obſerve the uſual law: and abſorb caloric during ſolution. Now as their difference, in the cryſtallized and uncryſtallized ſtate, depends chiefly on their containing, in the former but not in the latter, water chemically combined; we may infer, that the cold, produced during the ſolution of ſalts, is occaſioned by the converſion of the water, which exiſts in theſe bodies, from a ſolid to a liquid form.

5. *During the ſolution of ſalts in water, a quantity of air is diſengaged.* This air was, partly, contained mechanically in the ſalt, and partly in the water. That it does not ariſe, entirely, from the former ſource, is proved by varying the experiment, in the following manner. Let an ounce or two of ſulphate of ſoda be put into a phial; and pour on this as much water as will completely fill the bottle. The air, contained in the pores of the ſalt, will be thus diſengaged; but only a ſmall portion of the ſalt will be diſſolved, agreeably

to the principle laid down. Art. 1, No. 7. Let the phial be ſhaken, and the whole of the ſalt will diſappear; a freſh portion of air being liberated during ſolution. The air that now appears, is extricated from the water, in conſequence of the affinity between the water and the ſalt, being ſtronger than that between the water and the air. It is, therefore, a caſe of ſingle elective affinity.

6. *During the ſolution of bodies, the bulk of water changes.* Take a glaſs globe, furniſhed with a long narrow neck (commonly termed a matraſs) and put into it an ounce or two of ſulphate of ſoda. Then add as much water as will fill the globe, and about three-fourths of the neck. This ſhould be done with as little agitation as poſſible, in order that the ſalt may not diſſolve, till required. Mark, by tying a little thread, the line where the water ſtands; and then agitate the matraſs. The ſalt will diſſolve; air will be ſet at liberty; and, during the ſolution, the water will ſink conſiderably below its level. This contraction of bulk is owing to the diminution of temperature; and when the water has regained its former temperature, it will alſo be found, that its bulk is increaſed by the addition of ſalt. The biſhop of Llandaff found that water exhibits a manifeſt augmentation of bulk, by diſſolving only the two thouſandth part of its weight of ſalt; a fact ſufficiently deciſive againſt that theory, which ſuppoſes pores in water, capable of receiving ſaline bodies without an augmentation of volume.

7. *Water has its ſolvent power increaſed by diminiſhing the preſſure of the atmoſphere.* Into a Florence flaſk, put a pound of ſulphate of ſoda; pour on it barely a pint of water; and apply heat ſo as to boil the water. The whole of the ſalt will be diſſolved. Boil the ſolution for ſeveral minutes, pretty ſtrongly, ſo as to drive out the air; and cork the bottle tightly, immediately on its removal from the fire. To prevent, more completely, the admiſſion of air, tie the cork over with blad-

der. As the veſſel cools, an imperfect vacuum will be formed over the ſolution; for the ſteam, which ariſes during the ebullition, expels the air, and takes its place. The ſteam is condenſed again, when the veſſel cools. The ſolution, when perfectly cold, may be ſhaken without any effect enſuing, ſo long as the veſſel is kept cloſely ſtopped; but on removing the cork, and ſhaking the veſſel, the ſolution will immediately congeal, and heat will be produced. This experiment, beſides the principle, which it is peculiarly intended to illuſtrate, exemplifies, alſo, the general rule laid down. Art. 11. No. 10. viz. that caloric is always evolved, during the tranſition of bodies from a fluid to a ſolid ſtate; and it furniſhes a fact exactly the converſe of that in which cold is produced, or caloric abſorbed, during the ſolution of ſalts.

8. It is unneceſſary to add any thing, to what has been already ſaid in a former ſection, reſpecting the combination of caloric with water, conſtituting ſteam; or to the hiſtory of the phenomena attending its converſion into ice; except that during the latter change, its bulk is enlarged in the proportion of 9 to 8, and that in conſequence of this expanſion, water, during congelation, is capable of burſting the ſtrongeſt veſſels; and becomes, alſo ſpecifically lighter. Hence ice ſwims always on the ſurface of water.

ART. X. *Alcalis.*

General Qualities.

The properties, common to all the three alcalis, may be ſhewn by thoſe of a ſolution of pure pot aſh.

A. The alcalis change vegetable blue colours, as that of an infuſion of violets, to green.

B. They have an acrid and peculiar taſte.

C. They ſerve as the intermedia between oils and water, ſee Art. 1, No. 9.

D. They corrode woollen cloth; and if the ſolution be ſufficiently ſtrong, reduce it to the form of a jelly.

Pure Pot-aſh, and pure Soda.

Theſe alcalis may be procured, in a dry ſtate, by evaporating their reſpective ſolutions, the mode of preparing which will be hereafter pointed out. The alcalis thus obtained, are very far from a ſtate of complete chemical purity. Their properties, alſo, in a ſolid form, are not particularly intereſting; as moſt of theſe may be exhibited in a ſtate of ſolution. It may be proper, however, to ſtate,

A. That they powerfully attract moiſture from the atmoſphere, or deliquiate.

B. They readily diſſolve in water, and produce heat during their ſolution.

C. They are not volatilized by a moderate heat, and hence have been called fixed alcalis.

Pure Ammonia.

1. Ammonia, in its pureſt form, ſubſiſts in the ſtate of a gas. In order to procure it, one of the following proceſſes may be employed.

A. Mix together equal parts of muriate of Ammonia and quicklime, each ſeparately powdered; and introduce them into a ſmall gas bottle or retort. Apply the heat of a lamp; and receive the gas, that is liberated, over mercury.

B. To a ſaturated ſolution of ammonia in water, or the pure liquid ammonia, in a gas bottle, apply the heat of a lamp, and collect the gas as in A.

2. This Gas has the following properties.

A. It has a ſtrong and very pungent ſmell.

B. It immediately extinguiſhes flame; and is fatal to animals.

C. It is lighter than atmoſpheric air. Hence a jar filled with this gas, and placed with its mouth upwards, is ſoon found to change its contents for common air, which, being heavier, deſcends, and diſplaces the ammoniacal gas.

D. It is not inflammable; nor does it explode when mixed with hydrogen gas.

E. It is rapidly abſorbed by water. A drop or two of water, being admitted to this gas, confined over mercury, the gas will be immediately abſorbed, and the mercury will riſe, ſo as to fill the whole of the jar, provided the gas be ſufficiently pure. Ice produces the ſame effect, in a ſtill more remarkable manner.

F. Water, by ſaturation with this gas, acquires its peculiar ſmell; and conſtitutes what has been called liquid ammonia; or, more properly, ſolution of pure ammonia in water. This ſolution again yields its gas on applying heat, (ſee No. 1. B.)

G. This gas is decompoſed by electricity. Provide a jar furniſhed with two conductors (as deſcribed, Art. VII, No. 3, E.) and having admitted about a cubic inch of ammoniacal gas, paſs through it a ſucceſſion of electrical diſcharges. When 150 or 200 ſhocks have been paſſed, the gas will have increaſed to three times its original bulk. Admit a ſmall quantity of water. The gas will not, as before, be completely abſorbed by the water; but a part will remain. Hence it appears that ſome new gas has been generated; and, on examination, it is found to be a mixture of hydrogen and azotic gaſſes.

H. The decompoſition of ammonia may, alſo, be eaſily ſhewn, by Galvanizing, with the apparatus deſcribed, page 42, a ſaturated ſolution of ammonia in water. In this experiment, a conſiderable quantity of gas is produced. Expoſe this over a ſolution of ſulphuret of pot-aſh. A ſmall part of it will diſappear, being oxygenous gas. The remainder conſiſts of hydrogenous and azotic gaſſes.

Acidifiable Bodies—Acids—Combinations of Acids with Alcalis.

ART. XI. *Acids in General.*

Acids in general have the following properties:

A. *They redden vegetable blue colours.* Hence blue vegetable infuſions, and the papers ſtained with them, are teſts of the preſence of acids. To a little of the infuſion of litmus, add a drop of dilute ſulphuric, or any other acid. The colour will immediately change to red.

B. They have a peculiar taſte, expreſſed by the terms acid or ſour.

C. *They combine chemically with alcalis, and totally deſtroy the peculiar properties of thoſe bodies.* Let a few ounce meaſures of water be tinged blue with genuine ſyrup of violets. Add ſome ſolution of pure pot aſh, and the colour will become green. Then gradually drop in ſulphuric acid, much diluted; and if this be done very cautiouſly, the blue colour will be reſtored. In this ſtate, neither the alcali nor acid is in exceſs; or, in other words, they are exactly *ſaturated* with each other. One of the moſt remarkable properties of the alcali and the acid, when ſeparate, diſappears, therefore, on combination. And, on further examination, it will be found that all the other characteriſtics of the components are loſt in the compound.

ART. XII. *Carbon—Carbonic Acid—Carbonates—Other Binary Compounds of Carbon.*

1. Carbon is obtained, though not abſolutely pure, yet ſufficiently ſo for the purpoſes of exhibition, by charring, in a covered crucible, pieces of oak, willow, hazle, or other woods, from which the bark has been previouſly peeled. For purpoſes, to which it is applied in a powdered ſtate, it may be purified, by powder-

ing it, and waſhing it firſt with dilute muriatic acid, to ſeparate any earths it may contain, and afterward with repeated affuſions of diſtilled water.

2. In its aggregated ſtate, carbon is black; perfectly inſipid, and free from ſmell; brittle, and eaſily pulverized.

Combination of Carbon with Oxygen.

3. If a piece of charcoal be introduced cold into oxygenous gas, no effect will enſue; but if the charcoal be previouſly made red-hot, it burns in this gas with conſiderable brilliancy. To perform this experiment with accuracy, and with the proper attention to the products, it ſhould be made over mercury. The oxygen will unite with the carbon; and the product is a compound of carbon and oxygen, which ſubſiſts over mercury in the ſtate of gas. On this account no diminution enſues.

4. Another mode of effecting the combination of carbon with oxygen, is by driving the vapour of water over red-hot charcoal, in an apparatus ſimilar to that deſcribed, page 29, B. The water is decompoſed; its oxygen combines with the carbon; while its hydrogen combines with another portion of carbon, and forms a compound, which will be hereafter deſcribed.

The union of carbon with oxygen, however produced, furniſhes a compound, called

Carbonic Acid.

1. To procure carbonic acid, ſufficiently pure for the exhibition of its properties, neither of the above proceſſes is adviſable. The ſtudent may, therefore, have recourſe to another, the rationale of which he will not, at preſent underſtand; but which will be explained afterward. Into a common gas bottle, put a little powdered marble or chalk, and pour, on this, ſulphuric acid diluted with 5 or 6 times its weight of water. A gas will be produced, which thoſe, who have an opportunity, may receive over mercury; but a mercurial

apparatus is not abſolutely eſſential; ſince the gas may be collected over water, if uſed immediately when procured. Its properties are the following:

A. *It extinguiſhes flame.* Set a veſſel, filled with the gas, with its mouth upwards, and let down a lighted candle. The candle will inſtantly be extinguiſhed.

B. *It is fatal to animals.* Put a mouſe or other ſmall animal into a veſſel of the gas, and cover the veſſel to prevent the contact of common air. The animal will die in the courſe of a minute or two.

C. *This gas is heavier than common air.* Let a long glaſs tube, proceeding from a gas bottle containing the materials (No. 1.) be twice bent at right angles, like thoſe figured in Lavoiſier's 4th plate, fig. 1, E. Let the open end of the longer leg reach the bottom of a glaſs jar, perfectly dry within, and ſtanding with its mouth uppermoſt. The carbonic acid will expel the common air from the jar, becauſe it is heavier. This ſuperior gravity may be further ſhewn as follows: When the jar is perfectly filled with the gas (which may be known by a lighted candle being inſtantly extinguiſhed when let down into it) take another jar, of rather ſmaller ſize, and place, at the bottom of it, a lighted taper ſupported by a ſtand. Then pour the contents of the firſt mentioned jar into the ſecond, as if you were pouring water. The candle will be inſtantly extinguiſhed, as effectually, as if it had been immerſed in water.

It is owing to its ſuperior gravity, that carbonic acid gas is often found at the bottom of deep wells and of mines, the upper part of which is entirely free from it. Hence the precaution, uſed by the ſinkers of wells, of letting down a lighted candle, before they venture to deſcend in perſon.

D. *Carbonic acid gas is abſorbed by water.* Fill partly a jar with this gas, and let is ſtand a few hours over water. An abſorption will gradually go on, till at laſt none will remain. This abſorption is infinitely quicker, when agitation is uſed, Repeat the above experiment, with this difference, that the jar muſt be ſhaken ſtrongly. A very rapid diminution will now take place. In this manner water may be charged with its own bulk of carbonic acid gas; and it acquires, when thus ſaturated, a very briſk and pleaſant taſte. This impregnation is moſt commodiouſly effected in an apparatus, ſold in the glaſs ſhops, under the name of Nooth's machine.

E. From water, thus impregnated, carbonic acid is again ſet at liberty, on boiling the water, or on expoſing it under the receiver of an air pump. During exhauſtion, the gas will eſcape ſo rapidly, as to preſent the appearance of ebullition; and will be much more remarkable than the diſcharge of air from a jar full of common ſpring water, confined, at the ſame time, under the receiver, as a ſtandard of compariſon.

F. *Carbonic acid gas, when combined with water, reddens vegetable blue colours.* This may be ſhown by dipping, into water thus ſaturated, a bit of litmus paper; or by mixing, with a portion of it, about an equal bulk of the infuſion of litmus. This fact eſtabliſhes the title of the gas to be ranked among acids.

G. *Carbonic acid gas precipitates lime water.* This character of the gas is neceſſary to be known; becauſe it affords a ready teſt of the preſence of carbonic acid, whenever it is ſuſpected. Paſs the gas, as it proceeds from the materials, through a portion of lime water. This, though perfectly tranſparent before, will inſtantly grow milky. Or mix equal meaſures of water ſaturated with carbonic acid, and lime water. The ſame precipitation will enſue.

11. *By the application of the teſt G, it will be found, that carbonic acid is generated in ſeveral caſes of combuſtion.* Fill the pneumato-chemical trough with lime water, and burn a candle, in a jar filled with atmoſpheric air, over the lime water, till the flame is extinguiſhed. On agitating the jar, the lime water will become milky.—The ſame appearances will take place, more

ſpeedily and remarkably, if oxygenous gas be ſubſtituted. The carbonic acid, thus formed during combuſtion, by its admixture with the reſiduary air, renders it unfit for ſupporting flame, ſooner than it otherwiſe would be. Hence, if a candle be burnt in oxygenous gas, it is extinguiſhed, long before the oxygen is totally abſorbed, becauſe the admixture of carbonic acid with oxygen gas, in conſiderable proportion, unfits it for ſupporting combuſtion. Whenever any ſubſtance, by combuſtion in oxygenous gas or common air, over lime water, gives a precipitate, ſoluble with effervefcence in muriatic acid, we may confidently infer that it contains carbon.

1. *The reſpiration of animals is another ſource of carbonic acid.* On confining an animal, in a given portion of atmoſpheric air, over lime water, this production of carbonic acid is evinced by a precipitation. The ſame effect is, alſo, produced more remarkably in oxygenous gas. The production of carbonic acid by reſpiration, may be proved, alſo, by blowing the air from the lungs, with the aid of a quill, through lime water, which will immediately grow milky. The carbonic acid, thus added to the air, unfits it for ſupporting life, not merely by diminiſhing the proportion of oxygen gas, but apparently by exerting a poſitively noxious effect. Hence a given quantity of air will ſupport an animal much longer, when the carbonic acid is removed as faſt as formed, than when ſuffered to remain in a ſtate of mixture. It has been found that an atmoſphere, conſiſting of oxygen gas, and carbonic acid, is fatal to animals, though it contain a larger proportion of oxygen, than the air we commonly breathe.

2. *Carbonic acid gas exerts powerful effects on living vegetables.* Theſe effects, however, vary according to the mode of its application.

Water, ſaturated with this gas, proves highly nutritive, when applied to the roots of plants. The carbonic acid is decompoſed, its carbon forming a component part of the vegetable, and its oxygen being liberated in a gaſſeous form.

On the contrary, carbonic acid applied as an atmoſphere, by confining a living vegetable in this gas over mercury, is injurious to the health of the plant, eſpecially in the ſhade. M. Sauſſure, jun. found that a proportion of carbonic acid in common air, greater than one eighth, is always injurious to vegetation; but that in this proportion it promotes their growth, and is manifeſtly decompoſed.

Carbonates in General.

Carbonic acid is ſuſceptible of combination with alkalis, earths, and metals, and forms an order of compounds termed carbonates. At preſent, however, we ſhall only attend to the reſults of its union with alkalis.

Carbonate of Pot-aſh.

A. *Carbonic acid gas is very abundantly abſorbed by a ſolution of pure pot-aſh.* The ſimpleſt mode of ſhewing this is the following: Fill a common phial with this gas over water; and when full, ſtop it by applying the thumb. Then invert the bottle in a ſolution of pure pot-aſh, contained in a cup, and rather more in quantity than is ſufficient to fill the bottle. The ſolution will riſe into the bottle, and, if the gas be pure, will fill it entirely. Pour out the alcaline liquor; fill the bottle with water; and again diſplace it by the gas. Proceed as before; and repeat the proceſs ſeveral times. It will be found that the ſolution will condenſe many times its bulk of the gas; whereas water combines only with its own volume.

B. *The changes effected in the alcali may next be examined.* It will be found to have loſt much of its corroſive and penetrating taſte, and will no longer deſtroy the texture of woollen cloth; but it ſtill turns green the blue infuſion of vegetables. Before its abſorption of this gas, no remarkable change enſued, on mixing it with diluted ſulphuric acid; but if this, or any other acid, be now added, a violent effervefcence will enſue, ariſing from the eſcape of the gas, that had been previouſly abſorbed. If the mixture be made in a gas bottle, the gas, that is evolved, may be collected, and will be found to exhibit every character of carbonic acid.

C. In this ſtate of combination with carbonic acid, pot-aſh generally occurs in the arts. The pot-aſh, and pearl-aſh of commerce; and the ſalt of tartar and ſalt of wormwood of the ſhops, are carbonates of pot-aſh of different degrees of purity. The quantity of carbonic acid, contained in theſe alcalis, may be learned by a very ſimple experiment. Put one or two hundred grains of the alcali into a Florence flaſk, and add a few ounce meaſures of water. Take, alſo, a phial filled with dilute ſulphuric acid, and place this, as well as the flaſk, in one ſcale. Balance the two, by putting weights into the oppoſite ſcale; and when the equilibrium is attained, pour gradually the acid into the flaſk of alcali, till an effervefcence no longer enſues. When this has ceaſed, the ſcale containing the weights will be found to preponderate. This ſhews that the alcali, by combination with an acid, loſes conſiderably of its weight; and the exact amount of the loſs may be aſcertained, by adding weights to the ſcale containing the flaſk and phial, till the balance is reſtored.

D. As it is ſometimes of importance to know what proportion of real alcali a given weight of pot-aſh or pearl-aſh contains, it may be proper to point out how this information may be acquired. The ſtrength of the alcali is in proportion to the quantity of an acid required to ſaturate it. Thus if an ounce of one kind of pot-aſh requires, for ſaturation, a given quantity of ſulphuric acid; and an ounce, of another kind, requires twice that quantity, the latter is twice as ſtrong as the former. In order, however, to obtain a ſufficiently accurate ſtandard of compariſon, it will be neceſſary to employ, conſtantly, an acid of the ſame ſtrength. This may be effected, though not with abſolute uniformity, yet ſufficient for ordinary purpoſes, by diluting the common oil of vitriol of commerce to the ſame degree. For example, let the ſtandard of acid conſiſt of one part of ſulphuric acid, and five of water. The ſtrength of an alcali will be learned, by obſerving what quantity of this acid a given quantity of alcali requires for ſaturation. For this purpoſe, put half an ounce of the alcali, or any other definite weight, into a jar with a few ounces of water, and filtre the ſolution; weigh the dilute acid employed, before adding it to the alcali; then pour it in gradually, till the effervescence ceaſes, and till the colour of litmus paper, which has been reddened with vinegar, ceaſes to be reſtored to blue. When this happens, the point of ſaturation will be attained. Weigh the bottle, to aſcertain how much acid has been added; and the loſs of weight will indicate the ſtrength of the alcali. Another leſs accurate mode of determining the ſtrength is founded on the following property of carbonate of pot-aſh.

E. *Carbonate of pot-aſh diſſolves very readily in water, which, at the ordinary temperature, takes up more than its own weight.* Hence, when an alcali, which ſhould conſiſt almoſt entirely of carbonate of pot-aſh, is adulterated, as very often happens, with ſubſtances of little ſolubility, the fraud may be detected by trying how much of one ounce will diſſolve in two or three ounce meaſures of water. In this way, I have detected an adulteration of one third. There are certain ſubſtances of ready ſolubility, however, which may be uſed in adulterating aſhes, as common ſalt for example; and, when this is done, we muſt have recourse to the above mentioned teſt, for the means of diſcovery.

F. Carbonate of pot-aſh, in the ſtates which have been already deſcribed, is far from being completely ſaturated with acid. This ſufficiently appears from its ſtrongly alcaline taſte. It may be made more [illegible] charged with carbonic acid, by [illegible] ſtreams of carbonic acid gas, in a Nooth's machine, or other apparatus. When a ſolution of alcali, after this treatment, is ſlowly evaporated, it forms regular cryſtals. In this ſtate the alcali conſtitutes the cryſtallized carbonate of pot-aſh, which contains, per cent. 40 parts of alcali, 43 of acid, and 17 of water. It has therefore a much larger proportion of water and of acid than the common carbonate, 100 parts of which are compoſed of 70 parts of alcali, 25 of acid, and 5 of water.

G. The cryſtallized carbonate differs from the common one in the regularity of its form; in the greater mildneſs of its taſte; in remaining dry when expoſed to a moiſt atmoſphere; and in being more ſparingly ſoluble in water, which at the ordinary temperature takes up only one fourth of its weight. When carefully prepared, this is the pureſt form, in which carbonate of pot-aſh can be obtained.

H. Carbonate of pot-aſh, in all its forms, is decompoſed by the ſtronger acids, as the ſulphuric, nitric, and muriatic, which unite with the alcali, and ſet the gas at liberty.

Carbonate of Soda.

A. The abſorption of carbonic acid gas, by a ſolution of pure ſoda, may be exhibited by experiments, ſimilar to thoſe directed to be made on the ſolution of pot-aſh. Indeed every thing that has been ſaid of the preceding carbonate, will apply to this; except that the carbonate of ſoda has a leſs ſtrong affinity for water. Hence it continues dry, when expoſed to the atmoſphere, and even gives up a part of its water of cryſtallization, the cryſtals loſing their tranſparency and ſomething of their weight. Hence, alſo, it requires a greater quantity of water for ſolution, than common carbonate of pot-aſh, water taking up only half its weight. The cryſtals, too, differ conſiderably in form and ſize from thoſe of the former carbonate.

The carbonate of ſoda is known in commerce by the names of barilla, foſſil or mineral alcali, &c. but as applied to the uſes of the arts it is never met with pure.

Carbonate of Ammonia.

A. Ammonia, in its pure ſtate, exiſts in the form of a gas, permanent over mercury only; and carbonic acid has, alſo, the form of an aerial fluid. But when theſe two gaſſes are mixed together, over mercury, in proper proportions, (viz. one meaſure of carbonic acid to two or three of alcaline gas) they each quit the ſtate of gas, and are entirely condenſed into a white ſolid body, termed carbonate of ammonia.

B. Carbonate of ammonia retains, in a conſiderable degree, the pungent ſmell of the pure volatile alcali. It is, alſo, u like the other carbonates, volatilized by a very moderate heat; and evaporates without entering previouſly into a liquid ſtate. The vapour, that ariſes, may be again condenſed, in a ſolid ſtate; affording an example of *ſublimation*. This may be ſhewn, by applying heat to the carbonate of ammonia in a retort, to which a receiver is adapted. The carbonate will riſe and be condenſed in the receiver in the form of a white cruſt.

C. This carbonate does not attract moiſture from the air, but on the contrary, loſes weight. Its other properties reſemble thoſe of the carbonates of pot aſh and ſoda. The mode of preparing it will be deſcribed hereafter.

Combination of Carbon with Hydrogen, forming carbonated Hydrogenous Gas.

1. When water is decompoſed, by paſſing its vapour over red hot charcoal,* we obtain two different products.

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* See Lavoiſier's Elements, chapter viii.

Carbonic acid is ſormed, in conſequence of the union of the carbon with the oxygen of the water; and the hydrogen of the water, combining with another portion of carbon, conſtitutes the carbonated hydrogenous gas. The carbonic acid may be ſeparated by agitating the produced gas in contact with lime and water, mixed together ſo as to be of the conſiſtence of cream; and the carbonated hydrogen gas will remain pure.

2. This gas has the following qualities.

A. *It is not abſorbed by water.*

B. *It is inflammable.* This may be ſhewn by burning it in the manner directed in Art. VII. No. 3, B. The colour of the flame, however, may be obſerved to differ from that of hydrogen gas, inclining rather to a deep blue.

C. *When fired over mercury, carbonic acid gas and water are the products.* In burning pure hydrogen gas, water only is generated; but in the combuſtion of this gas, two inflammable bodies are preſent, viz. hydrogen and carbon. The production of carbonic acid may, alſo, be ſhewn by burning the gas over lime water, by means of a bladder and bent pipe, as directed page 28, A. The lime water will ſoon become milky.

D. *This gas is heavier than pure hydrogen gas*, and even than common atmoſpheric air. Soap bubbles, blown with it, deſcend like the common ones; and a jar filled with it, and held inverted a few minutes, exchanges its contents for common air.

ART. XIII. *Sulphur—Sulphuric Acid—Sulphates.—Binary compounds of Sulphur.*

Sulphur.

1. *Sulphur occurs in two different forms*; that of flowers and of ſtick ſulphur. The former is generally pureſt.

2. *Sulphur is readily fuſed.* A very gentle heat is ſufficient to melt it; and if very ſlowly cooled, it forms regular cryſtals.

3. *Sulphur is volatilized by heat.* A little ſulphur may be put into the bottom of a tube, the mouth of which is looſely ſtopped with paper, to prevent the free acceſs of air. On applying heat, the ſulphur will riſe to the top of the tube.

4. *Sulphur does not diſſolve in water.*

5. *It is inflammable.* In the open air, it burns with a blue flame, and emits a very penetrating ſmell. When burnt in a confined portion of common air, an abſorption takes place; but the ſulphur is extinguiſhed, before the whole of the oxygen is conſumed. In oxygenous gas, it burns with a very beautiful and brilliant light; and the abſorption is more remarkable, but is ſtill far from being complete. The product of both theſe combuſtions, is

Sulphuric Acid.[*]

1. Though this is not the mode, in which ſulphuric acid is ordinarily prepared; yet it will be proper for the chemical ſtudent to examine the reſult of this combuſtion, on account of the ſimplicity of the proceſs. Let the glaſs bell, under which ſulphur has been burnt, be rinſed out with a little water. This water will have an acid taſte; will turn vegetable blue colours red; and will efferveſce with carbonated alkalis. It is, therefore, an acid, and as it is compoſed of ſulphur and oxygen, it is termed the ſulphuric acid. The properties of this acid muſt be exhibited by a portion of that uſually found in the ſhops, or contained in the cheſt. They are as follows.

A. *Sulphuric acid has a thick and oily conſiſtence*; as may be ſeen by pouring it from one veſſel into another.

B. *It is nearly twice as heavy as water.* This will appear from weighing a ſmall phial filled with the acid; and afterward filled with diſtilled water.

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[*] Much ſulphureous acid is, alſo, generated in theſe proceſſes.

C. *In a pure ſtate it is perfectly limpid and colourleſs.*

D. *When mixed ſuddenly with water, conſiderable heat is produced.* A diminution of bulk, alſo enſues; that is, one meaſure of acid and one of water do not occupy the ſpace of two meaſures, but conſiderably leſs. Owing to the heat produced by its admixture with water, the dilution ſhould be conducted very gradually; and the acid ſhould be added to the water by ſmall portions at once, allowing each portion to cool, before a freſh addition is made. On the principle of its attraction for water, is to be explained, alſo, the rapid increaſe of weight, which the acid acquires, when expoſed to air.

E. *A perfectly pure ſulphuric acid remains quite limpid during dilution.* The ſulphuric acid, however, commonly found in the ſhops, under the name of oil of vitriol, on admixture with water, depoſits a white powder, in conſiderable quantity, conſiſting of various impurities.

F. *To purify ſulphuric acid,* it muſt be diſtilled in a glaſs retort, placed in the ſand bed of a reverberatory furnace. This proceſs is a very difficult one; and an inexperienced Chemiſt ſhould, therefore, not attempt it. It may be leſs perfectly purified, by diluting it with an equal weight of water; allowing the impurities to ſettle; decanting the clear liquor; and evaporating it, to the proper degree, in a glaſs veſſel.

G. *Sulphuric acid is decompoſed at the temperature of the atmoſphere, by inflammable ſubſtances, and acquires a dark colour.* The addition of a little brown ſugar, or a drop of oil, to a portion of the acid, imparts to it a browniſh hue, which in time changes to black. Hence this acid ſhould always be kept in bottles with glaſs ſtoppers; for a ſmall bit of cork, if dropped into a conſiderable quantity, changes it in the manner that has been pointed out.

H. *In high temperatures, ſulphuric acid is ſtill farther decompoſed by combuſtible bodies.* Into a glaſs retort put ſuch a quantity of ſulphuric acid, as will fill about one-fourth part of it; and add a ſmall portion of powdered charcoal. On applying the heat of a lamp, gas will be produced very abundantly. Let this gas be conveyed, by a tube fixed to the mouth of a retort, and bent in the proper manner, into an inverted jar of water; or, if it can be had, into an inverted jar of quickſilver, in a mercurial apparatus. During this operation, the carbon attracts part of the oxygen of the ſulphuric acid, and forms carbonic acid gas. But the ſulphur is not entirely diſoxygenated; and a compound is, therefore, formed of ſulphur and oxygen, containing leſs oxygen than the ſulphuric acid. This compound exiſts in the ſtate of a gas, and its properties may next be examined. To avoid, however, the complication, which the admixture of carbonic acid with this new product introduces into the experiments, it may be proper to prepare it in a mode leſs objectionable, but the rationale of which cannot at preſent be explained. This conſiſts in diſſolving one part by weight of quickſilver in two of ſulphuric acid, and boiling the maſs to dryneſs. The dried maſs, ſtill remaining in the retort, is next to be diſtilled in a ſtrong ſand heat; a glaſs globe being interpoſed between the retort and the receiving trough, to condenſe any ſulphuric acid that may eſcape decompoſition (ſee Lavoiſier's 4th plate, fig. 1, G). The gas thus obtained, is termed, conformably to the principles of the new nomenclature,—

Sulphureous acid Gas.

Its properties are the following.

A. *It has a pungent and ſuffocating ſmell,* exactly reſembling that which ariſes from burning ſulphur.

B. *It is heavier than atmoſpherical air.*

C. *It extinguiſhes burning bodies, and kills animals.*

D. *Is has the property of whitening or bleaching ſilk.*

E. *It is abſorbed by water*; but only in ſmall proportion.

F. *This watery ſolution does not redden infuſion of litmus*, as acids in general do, but totally deſtroys its colour.

G. *Sulphuric acid, ſaturated with this Gas*, (which may be effected by paſſing the gas through the acid) *acquires the property of aſſuming a ſolid form*, by a moderate reduction of its temperature.

H. *Sulphureous acid is again converted to the state of ſulphuric, by reſtoring oxygen to it.* To a portion of water ſaturated with this gas, add a little oxyd of manganeſe, a ſubſtance that contains much oxygen looſely combined. The pungent ſmell of the water, and the other characteriſtics of ſulphureous acid, will ſoon diſappear.

Both theſe acids are ſuſceptible of combination with alkalis.

Combination of Sulphuric Acid with Alkalis.

Sulphate of Pot-aſh.

This ſalt may be formed by ſaturating the carbonate of pot-aſh with ſulphuric acid, and cryſtalizing the ſolution. Its properties are the following.

A. *It cryſtallizes* in ſmall ſix ſided priſms, terminated by ſix-ſided pyramids, with triangular faces.

B. *It has a bitter taſte.*

C. *It decrepitates*, or crackles, when thrown on a red hot iron, or on red hot coals, and is volatilized in a ſtrong heat.

D. *Water at* 60° *of Fahrenheit, takes up only one-ſixteenth of its weight*; but boiling water diſſolves one-fifth.

E. 100 parts contain 30.21 acid, 64.61 alkali, and 5.18 water.

G. *This ſulphate is decompoſed, in high temperatures, by carbon.* Mix any quantity of the ſalt with one-fourth of its weight of charcoal finely powdered; and expoſe the mixture, in a crucible, to a ſtrong heat. The carbon will unite with the oxygen of the ſulphuric acid, and will eſcape in the ſtate of a gas. What remains is a compound, hereafter to be deſcribed, of ſulphur and pot-aſh.

Sulphate of Soda.

A. This ſalt forms regular octahedral cryſtals, of a priſmatic or cuneiform figure, the two terminating pyramids of which are truncated near their baſis.

B. It has a more bitter taſte than the preceding, and melts more eaſily in the mouth.

C. It ſwells upon a heated iron, in conſequence of the loſs of its water of cryſtallization, and a white powder is left.

D. By expoſure to the atmoſphere, it effloreſces and loſes weight,

E. It is very ſoluble in water, 3 parts of which at 60° of temperature, diſſolve one of the ſalt; and boiling water diſſolves its own weight.

F. It contains per cent, 14 acid, 22 alkali, and 64 water.

G. It is decompoſed by charcoal like the preceding ſalt, and a compound remains of ſulphur and ſoda.

Sulphate of Ammonia.

A. The ſulphate of ammonia forms long flattened priſms with ſix ſides terminated by ſix-ſided pyramids.

B. It ſlightly attracts moiſture from the air.

C. It liquefies by a gentle heat, and is volatilized. If a ſtronger heat be applied, it is decompoſed. See Mr. Hatchett's paper in Phil. Trans. 1796, or Davy's Reſearches.

D. The pure fixed alkalis, pot-aſh and ſoda, ſeize the ſulphuric acid, and ſet at liberty the alkali. Hence a ſtrong ſmell of ammonia ariſes, on the admixture of pure ſoda or pot-aſh with this ſalt.

The combinations of ſulphureous acid with alkalis have no peculiar qualities that are likely to prove intereſting to the general ſtudent. Thoſe, however, who may wiſh to purſue this ſubject, I refer to ſome intereſting papers in the Annales de Chimie, vols. 2 and 24.

Binary Compounds of Sulphur—1ſt. With Alkalis.—2d. With Hydrogen.

The combinations of ſulphur with the two fixed alkalis, ſoda and pot-aſh, are ſo ſimilar in properties, that what is ſaid of the one will equally apply to the other.

1. Sulphur may be united with theſe alkalis, either in the dry or humid way. To prepare a ſulphuret, in the dry way, mix equal parts of ſulphur and of carbonate of pot-aſh or ſoda, in a perfectly dry ſtate; and fuſe the mixture in a crucible. The melted maſs, when poured out, will have a reddiſh or liver colour. Or, a ſulphuret may be formed by the decompoſition of ſulphates by charcoal, ſee preceding G. The proceſs, in the moiſt way, conſiſts in boiling together flowers of ſulphur and a ſolution of pure pot-aſh or ſoda in a glaſs veſſel. The ſulphur is thus diſſolved.

2. Sulphurets of alkalis have the following qualities.

A. *In a moiſt ſtate they emit an offenſive ſmell, and have a diſagreeable taſte.*

B. *They change to green the colour of violets,* in the ſame manner as uncombined alkalis.

C. *They blacken the ſkin,* ſilk, and other animal ſubſtances.

D. *They are decompoſed by all acids.* Into a Nooth's machine put a weak ſolution of ſulphuret of alkali, and paſs through it ſtreams of carbonic acid gas. In the courſe of a few days, the ſulphur will be precipitated, and a carbonate of alkali obtained. This decompoſition enſues, inſtantly, on adding, to a ſolution of a ſulphuret, any of the ſtronger acids, as the ſulphuric, nitric, or muriatic; and we obtain a compound of the alkali with the reſpective acid employed.

E. *The liquid ſulphurets abſorb oxygenous gas.* This may be ſhown by the experiments already deſcribed. (Art. VI.) If the change thus effected be examined, it will be found that the oxygen has combined with the ſulphur, and formed ſulphuric acid, which, uniting with the alkali, has compoſed the ſulphate of pot-aſh.

F. If dilute muriatic acid be poured on the ſolution of ſulphuret of pot-aſh or ſoda, a violent effervescence will enſue, and a very offenſive gas be diſengaged. This gas may be collected over water. It is termed

Sulphurated Hydrogen Gas.

1. This gas may be obtained in the foregoing manner; or from a mixture of three parts by weight of iron filings and one of ſulphur, previouſly melted together in a covered crucible. A portion of the fuſed maſs may be put into a gas bottle, and diluted ſulphuric or muriatic acid poured on it, which will extricate the ſulphurated hydrogen gas.

2. Its properties are the following:

A. *Its ſmell* is extremely offenſive, reſembling that of putrefied eggs.

B. *It is inflammable*, and burns either ſilently or with an exploſion, accordingly as it is previouſly mixed or not with oxygen gas or atmoſpheric air. During this combuſtion, water reſults from the union of the hydrogen with the oxygen, and ſulphuric and ſulphureous acids from that of the oxygen and ſulphur.

C. *It tarniſhes ſilver*, mercury, and other poliſhed metals, and inſtantly blackens white paint.

D. *It is abſorbed by water*, which thus acquires the peculiar ſmell of the gas. It is this gas which gives to the Harrogate, and ſome other natural waters, their peculiar ſmell.

E. *Water ſaturated with this gas turns green the infuſion of violets*, in this reſpect producing the effect of an alkali.

F. *It is copiouſly abſorbed by alkalis*, which thus acquire colour, ſmell, and the property of diminiſhing oxygen gas. The compounds of this gas with alkalis are termed hydro ſulphurets. Thus, the compound of this gas with pot-aſh is named hydro ſulphuret of pot-aſh, and differs from the ſulphuret of pot-aſh, in containing hydrogen beſides ſulphur. From theſe combinations, the gas is liberated by acids.

ART. XIV. *Combination of Azote with Oxygen, Conſtituting Nitric Acid—Nitrous Gas—Nitrous Oxyd—and Compounds of Nitric Acid with Alkalis.*

1. The direct combination of azote and oxygen, affording a deciſive ſynthetic proof of the nature of this acid, may be effected by paſſing the electric ſhock through a mixture of azotic and oxygen gaſſes. The circumſtances of this experiment, however, cannot be underſtood without the aid of a plate, and of a very detailed deſcription, for both of which I muſt refer to Mr. Cavendiſh's paper in the Phil. Trans. for 1785, &c.

2. The analyſis of the acid may be obtained by driving it through a red hot porcelain tube, and receiving the generated gaſſes, which turn out to be a mixture of azotic and oxygenous gaſſes.

3. The nitric acid has the following properties.

A. *It is heavier than water*, in the proportion of 1.5 to 1.

B. *It is perfectly limpid and colourleſs.*

C. *It gives a yellow ſtain to the ſkin.*

atmoſpheric air or oxygen gas, it will be immediately reddened.

G. *That the peculiar acid, thus produced, is the nitrous*, will appear from the following experiment. Into a jar filled with, and inverted in mercury, paſs a ſmall quantity of a ſolution of pure pot-aſh; and afterwards, meaſures of oxygen and nitrous gaſſes, ſeparately, and in proper proportion. On removing the ſolution from the jar; expoſing it, for ſome time, to the atmoſphere; and afterwards evaporating it, cryſtals of nitrate of pot-aſh will be formed, a ſalt which is aſcertained to be formed of pot-aſh and nitrous acid.

H. *Nitrous gas is abſorbed by nitric acid*, which, by this abſorption, is conſiderably changed in its properties. Paſs the gas, as it iſſues from the materials that afford it, through colourleſs nitric acid. The acid will undergo ſucceſſive changes of colour, till at laſt it will become orange coloured and fuming. In this ſtate it is called nitrous acid, becauſe it contains a leſs proportion of oxygen than the colourleſs nitric.

I. *The nitrous gas, thus abſorbed, is expelled again, by a gentle heat.* This may be ſhewn by gently heating the acid coloured in expt. H, till it again becomes limpid. In this experiment, light ſhould be excluded.

K. *Nitrous gas is decompoſed, by expoſure to bodies that have a ſtrong affinity for oxygen.* Thus iron filings decompoſe it, and become oxyded, affording a proof of the preſence of oxygen in this gas. Sulphuret of pot-aſh, &c. have a ſimilar effect.

L. *Nitrous gas is abſorbed by the green ſulphate and muriate of iron*,* which do not abſorb azotic gas. To aſcertain, therefore, how much azotic gas a given quantity of nitrous gas contains, let it be expoſed in a graduated tube over one of theſe ſolutions. This information is neceſſary, previouſly to deducing, from its effects on atmoſpheric air, the proportion of oxygen gas.

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* For an account of theſe ſalts, ſee Art. xxiv.

M. *A very intereſting experiment, affording a ſynthetic proof of the conſtitution of nitrous gas*, we owe to Dr. Milner, of Cambridge*. Into an earthen tube, about 20 inches long, and $\frac{3}{4}$ inch wide, open at both ends, put as much coarſely powdered mangane ſe, as is ſufficient nearly to fill it. Let this be placed, horizontally, in a furnace, having two openings oppoſite to each other. To one end of the earthen tube adapt a retort, containing a ſtrong ſolution in water of pure ammonia, and to the other a bent glaſs tube. Let a fire be kindled in the furnace; and when the mangane ſe may be ſuppoſed to be red hot, drive over it the vapour of the ammonia. The alkali will be decompoſed; its hydrogen, uniting with part of the oxygen combined with the mangane ſe, will form water; while its azote, uniting with another portion of the oxygen, will conſtitute nitrous gas. The gas, thus generated, may be collected by the uſual apparatus.

N. *Another fact, ſhewing the mutual relation of ammonia and of the compounds of azote, was diſcovered, ſome years ago, by Mr. Wm. Higgins.*† Moiſten ſome powdered tin (which is ſold under this name by the druggiſts) with ſtrong nitric acid; and when the red fumes have ceaſed to ariſe, add ſome quick-lime, or ſolution of pure pot-aſh. A ſtrong ſmell of ammonia will be immediately produced.

Gaſeous Oxyd of Azote—Nitrous Oxyd of Davy.

1. This compound, alſo conſiſting of oxygen and azote, but in different proportions, may be obtained by ſeveral proceſſes.

A. By expoſing common nitrous gas, for a few days, to iron filings, or to various other bodies ſtrongly attracting oxygen, this gas is changed into the gaſſeous oxyd.

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* Phil. Trans. 1789.

† See his Comparative View of the Phlogiſtic and Anti-Phlogiſtic Theories, 2d edition, page 309, note.

B. By diſſolving zinc or tin in dilute nitric acid.—But by neither of theſe proceſſes, is the gas obtained ſufficiently pure, for exhibiting its qualities. To procure it in a state of purity, the following proceſs is the beſt.

C. To dilute nitric acid, add carbonate of ammonia, till the acid is ſaturated. Then evaporate the ſolution; and to ſupply the waſte of aklali, add occaſionally a little more of the carbonate. Let the ſolution be evaporated, by a very gentle heat, to dryneſs. The ſalt thus obtained, is next to be put into a glaſs retort, and diſtilled with a ſand heat, not exceeding 500° Fahrenheit. The heat of an Argand's lamp is even ſufficient. The gas may be collected over water, and allowed to ſtand a few hours, before it is uſed; during which time it will depoſit a white cloud, and will become perfectly tranſparent.

The gas thus obtained, was termed by the ſociety of Dutch Chemiſts, gaſeous oxyd of azote, but for the ſake of brevity, and as more conformable to the nomenclature of other compounds of azote, I ſhall uſe, with Mr. Davy, the name of nitrous oxyd.*

This Gas has the following properties.

A. *A Candle* burns in this gas with a brilliant flame and crackling noiſe. Before its extinction, the white inner flame becomes ſurrounded with an exterior blue one.

B. *Phoſphorus* introduced into it in a state of inflammation burns with increaſed ſplendor.

C. *Sulphur*, introduced into it when burning with a feeble blue flame is inſtantly extinguiſhed. But when ſtate of active inflammation, it burns with a vivid and beautiful roſe coloured flame.

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* For a full account of of this gas, conſult Mr. Davy's Reſearches, Chemical and Philoſophical. London. Johnſon, 1800.

D. *Red hot charcoal* burns in it more brilliantly than in the atmoſphere.

E. *Iron wire* burns in this gas with much the ſame appearances as in oxygenous gas.

F. *It is rapidly abſorbed by water that has been previouſly boiled*, about $\frac{1}{50}$ the original bulk of the gas remaining uncondenſed. A quantity of gas, equal to rather more than half the bulk of the water, may be thus made to diſappear.

G. *Water, that has been ſaturated with this gas, gives it out again, unchanged, when heated.*

H. *It does not change blue vegetable colours.*

I. *It has a diſtinctly ſweet taſte*, and a faint but agreeable odour.

K. *It is not diminiſhed* by admixture with either oxygen or nitrous gas.

L. *A mixture of this gas with hydrogen gas, detonates loudly.*

M. *Animals, when wholly confined in this gas, die ſpeedily.*

N. *One of the moſt extraordinary properties of this gas is exhibited in its action on the human body, when received into the lungs.* When thus employed, it does not prove fatal, becauſe, when received into the lungs, it is mixed and diluted with the atmoſpherical air, preſent in that organ. To adminiſter the gas, it may be introduced into an oiled ſilk bag, or clean bladder, furniſhed with a ſtop-cock; and may be breathed repeatedly from the bag, and back again, as long as it will laſt. The ſenſations, that are produced, vary greatly in perſons of different conſtitution; but in general, they are highly pleaſurable, and reſemble thoſe attendant on the pleaſant period of intoxication. Great exhilaration; an irreſiſtible propenſity to laughter; a rapid flow of vivid ideas; and an unuſual fitneſs for muſcular exertion, are the ordinary feelings it produces. Theſe pleaſant ſenſations, it muſt be added, are not ſucceeded, like thoſe accompanying the groſſer elevation from fermented liquors, by any ſubſequent depreſſion of nervous energy.

O. From the experiments of Mr. Davy, it appears that 100 parts by weight of this gas contain 36.7 oxygen, and 63.3 azote, or excluding decimals, 37 oxygen and 63 azote.

Nitrate of Pot-aſh.

A direct ſynthetic proof of the compoſition of this ſalt may be obtained by ſaturating nitric acid with pot-aſh, either pure, or in a carbonated ſtate. The ſolution on evaporation yields cryſtals of nitrate of pot-aſh, or nitre.

2. This ſalt has the following properties:

A. *It cryſtallizes* in priſmatic octahedrons; generally conſtituting ſix ſided priſms, terminated by two-ſided ſummits.

B. *For ſolution,* it requires ſeven times its weight of water at 60° of Faht. and boiling water takes up its own weight.

C. *By the application of a gentle heat, it fuſes,* and being caſt in moulds, forms what is called Sal Prunelle.

D. *If a red heat be applied, nitrate of pot-aſh is decompoſed, in conſequence of the deſtruction of its acid.* By diſtilling it in an earthen retort, or in a gun barrel, oxygenous gas may be obtained in great abundance, one pound of nitre yielding about 12000 cubic inches, of ſufficient purity for common experiments, but not for nice purpoſes.

E. *Nitrate of pot-aſh, that has been made red hot, ſeems to contain an acid leſs highly oxygenated than the common nitric acid,* and having a weaker affinity for alkalis. For if acetic acid be poured on nitre, that has been thus treated, the nitrous acid is expelled in red fumes; whereas common nitre is not at all affected by acetic acid.

F. *Nitrate of pot-aſh is rapidly decompoſed by charcoal.* This may be ſhewn by mixing two parts of powdered nitre with one of powdered charcoal, and ſetting fire to the mixture, in an iron veſſel, under a chimney. The products of this combuſtion, which may be collected by a proper apparatus, are carbonic acid and azotic gaſſes. Part of the carbonic acid, alſo, remains attached to the reſiduary alkali, and may be obtained from it on adding a ſtronger acid.

G. *Nitrate of pot-aſh is alſo decompoſed by ſulphur.* Mix powdered nitre and ſulphur; and throw the mixture, by little at a time, into a red hot crucible. The ſulphur will unite with the oxygen of the nitric acid, and form ſulphuric acid; which, combining with the pot-aſh, will afford ſulphate of pot-aſh. The production of the latter ſalt will be proved, by diſſolving the maſs remaining in the crucible; and cryſtallizing it, when a ſalt will be obtained exhibiting the characters deſcribed.

H. A mixture of three parts of powdered nitre, two of carbonate of pot-aſh, or common ſalt of tartar, and one part of ſulphur, all accurately mixed together, forms the *fulminating powder,* which explodes with a loud noiſe when laid on an iron heated below redneſs.

I. A mixture of five parts of powdered nitre, one part of ſulphur, and one of powdered charcoal, compoſes *gunpowder.* The materials muſt all be very finely powdered ſeparately; then mixed up together; and beaten with a wooden peſtle, a ſufficient quantity of water being added to prevent an exploſion. The mixture muſt afterward be granulated, by paſſing through ſieves, and dried.

K. *Nitrate of pot-aſh is alſo decompoſed by ſulphuric acid.* Put ſome coarſely pounded nitre into a retort, with half its weight of ſulphuric acid; adapt a receiver; and apply heat. The nitric acid will paſs over into the receiver; and, in the retort, will remain a compound of pot-aſh and ſulphuric acid.

Nitrate of ſoda is a ſalt not poſſeſſed of any properties that are generally intereſting. It may be formed, by ſaturating nitric acid with carbonate of ſoda, or by diſtilling common ſalt (muriate of ſoda) with nitric acid.

Nitrate of Ammonia.

This ſalt derives importance chiefly from its application to the purpoſe of obtaining nitrous oxyd; and, as the method of producing it and of obtaining from it the nitrous oxyd, have been already deſcribed, it is unneceſſary to add here any thing more concerning it.

Muriatic Acid—Oxygenated Muriatic Acid—and their Combinations with Alkalis.

1. The muriatic acid, in its pureſt form, exiſts in the ſtate of a gas, permanent over mercury only. For exhibiting its properties, therefore, a mercurial apparatus is abſolutely neceſſary.

2. Muriatic acid gas may be obtained, moſt commodiouſly, from dried muriate of ſoda, in a gas bottle, with half its weight of ſtrong ſulphuric acid. It exhibits the following properties:

A. *It has a very pungent ſmell.*

B. *When brought in contact with common air, it occaſions a white cloud.* This is owing to the moiſture always preſent in the atmoſphere.

C. *It extinguiſhes a lighted candle.*

D. *It is very rapidly abſorbed by water.* A drop or two of water, admitted to a large jar full of this gas, cauſes the whole of it inſtantly to diſappear.

3. Water, when charged as highly as poſſible with this gas, forms the ordinary muriatic acid in a liquid ſtate. This watery ſolution of muriatic acid has the following properties:

A. *It is heavier than water in the proportion of* 1170 to 1000.

B. *It emits white and ſuffocating fumes.*

C. *It is not acted on by inflammable ſubſtances*, even when conſiderable heat is applied.

D. *When diluted with water*, no remarkable degree of heat is produced.

E. *It combines with the alkalis*, and conſtitutes a peculiar genus of neutral ſalts.

Muriate of Pot-aſh.

This ſalt is not peculiarly intereſting.

Muriate of Soda.

Muriate of ſoda is that well known ſalt, now become a neceſſary ingredient in the food of man, and of great utility in ſeveral of the arts.

1. Its compoſition may be proved by the direct union of ſoda with muriatic acid.

2. Its qualities are as follow:

It requires for ſolution, twice and a half its weight of water, at 60° of Faht. and hot water takes up very little more. Hence its ſolution cryſtallizes, not like that of nitre, by cooling, but by evaporation.

B. *When heated gradually it fuſes*, and forms when cold a ſolid compact maſs.

C. If ſuddenly heated, as by throwing it on red hot coals, it *decrepitates*.

D. *It is not decompoſed when ignited in contact with inflammable ſubſtances.*

E. *When diſtilled with ſulphuric acid and water*, its acid is diſengaged, and there remains, in the retort, a compound of ſulphuric acid with ſoda.

Muriate of Ammonia.

1. If equal meaſures of ammoniacal gas, (ſee page 47,) and muriatic acid gas, be mixed together over mercury, they are immediately condenſed; a white cloud is formed; and a ſolid ſubſtance is depoſited on

the ſides of the veſſel. This is the muriate of ammonia. Its properties are as follow:

A. *It is volatilized,* without being decompoſed, and hence may be ſublimed.

B. *It is readily ſoluble in water,* three parts and a half of which at 60° take up one of the ſalt. During its ſolution much caloric is abſorbed.

C. *On the addition of a ſolution of pure pot-aſh or pure ſoda, the alkali is diſengaged,* as is evinced by the pungent ſmell that ariſes, on the mixture of two bodies perfectly inodorous when ſeparate.

D. *From this ſalt ſulphuric acid ſeparates the muriatic acid.* This may be proved by ſubſtituting it for common ſalt, in preparing muriatic acid gas.

Oxygenated Muriatic Acid.

1. This acid may be formed by either of the following proceſſes.

A. Into a ſtoppered retort, introduce eight ounces of liquid muriatic acid, and four ounces of finely powdered mangăneſe; and apply the heat of a lamp. A gas will be produced, which may be received over water in the uſual manner. From the foregoing materials about 160 cubical inches of gas may be obtained.

B. Mix eight ounces of muriate of ſoda (common ſalt) with three ounces of powdered manganeſe; put them into a ſtoppered retort, and pour on them four ounces of ſulphuric acid, diluted previouſly with four ounces of water, and which has been ſuffered to cool after dilution. On applying a gentle heat, gas will be produced as in A.

2. This gas has the following properties:

A. *It has a deep yellow colour.*

B. *It has a pungent and ſuffocating ſmell.* In experiments on this gas, great care ſhould be taken that it does not eſcape, in any conſiderable quantity, into the apartment; as its action on the lungs is extremely injurious and oppreſſive.

C. By a temperature of 40°, it is reduced into a liquid form, and is condenſed on the ſides of the veſſel. Hence ſome chemiſts have contended that it ſhould be claſſed among vapours, and not among gaſſes.

D. *When a burning candle is immerſed in the gas, the flame is enlarged, and a denſe ſmoke is produced.*

E. *Phoſphorus, introduced into it immediately takes fire,* and burns very brilliantly.

F. *Various metals, when minutely divided by filing,* as iron, zinc, biſmuth, tin, copper, &c. *take fire in this gas,* and burn with an extrication of heat and light.

G. *Sulphur is oxygenated by it,* and changed into ſulphuric acid.

H. *Charcoal, finely powdered and perfectly dry, takes fire in this gas.*

I. *The oxygenated muriatic gas deſtroys all vegetable colours.* This may be ſhewn by paſſing into it, through water, a piece of cloth, or of paper, ſtained with litmus, the colour of which will ſpeedily diſappear. Hence the application of this gas to the purpoſe of bleaching. Its efficacy, in this mode may be ſeen by confining in it a pattern of unbleached calico.

K. *This gas is abſorbed by water,* ſlowly if allowed to ſtand over it quieſcent, but rapidly when agitated.

L. *The watery ſolution acquires the colour and peculiar ſmell of the gas*; and has a ſimilar property of diſcharging vegetable colours. Hence it may be employed in bleaching.

M. *When the watery ſolution is expoſed to a temperature a little above that of freezing water, the gas, which is combined with it, ſeparates in the form of a liquid heavier than water.*

N. *When this ſolution is expoſed to the direct rays of the ſun, the oxygenated acid is decompoſed*; its oxygen eſcapes in the form of a gas; and it is reduced to the ſtate of common muriatic acid. The oxygenous gas may be collected, by expoſing the ſolution in a gas bottle, furniſhed with a bent tube, which terminates in the pneumato-chemical apparatus.

O. *The oxygenated muriatic acid combines with alkalis,* and forms peculiar compounds.

Oxygenated Muriate of Pot-aſh.

The properties of this ſalt were diſcovered by Berthollet. It may be formed by paſſing the oxygenated muriatic gas, as it proceeds from the mixture of muriate of ſoda, ſulphuric acid, and manganeſe, through a ſolution of cauſtic pot-aſh. This may be done by means of Woulfe's apparatus, uſing only one three necked bottle in addition to the balloon. The tube, which is immerſed in the alkaline ſolution, ſhould be at leaſt half an inch in diameter, to prevent its being choked up by any cryſtals that may form. The ſolution, when ſaturated with the gas, may be gently evaporated; and the firſt products only of cryſtals are to be reſerved for uſe. Their properties are the following:

A. *They have the form of ſhining hexaedral laminal or rhomboidal plates.*

B *One part of the ſalt requires* 17 *of cold water for ſolution*; *but* 5 *parts of hot water take up* 2 *of the ſalt.*

C. *When the oxygenated muriate is ſubmitted to diſtillation, in a coated retort, it firſt fuſes, and on a further increaſe of temperature yields oxygenous gas of great purity.* A hundred grains of ſalt afford 75 cubic inches of gas.

D. *The oxygenated muriate of pot-aſh has no power, of diſcharging vegetable colours*; but the addition of a little ſulphuric acid, by ſetting the oxygenated acid at liberty, developes this property.

E. *The ſalt is decompoſed by the ſtronger acids, as the ſulphuric and nitric acids.* This will be proved by dropping a few grains of the ſalt into a little ſtrong ſulphuric acid. A ſtrong ſmell will ariſe, and, if the quantities be ſufficiently large, an exploſion will enſue. The experiment ſhould, therefore, be made with caution.

F. *This ſalt exerts powerful effects on inflammable bodies.* (a) Rub two grains into powder in a mortar, and add one grain of ſulphur. Mix them very accurately by gentle triture, and then, having collected the mixture to one part of the mortar, preſs the peſtle down upon it ſuddenly and forcibly. A loud detonation will enſue. Or if the mixed ingredients be wrapped in ſome ſtrong paper, and then ſtruck with a hammer, a ſtill louder report will be produced.

(b) Mix five grains of the ſalt with half the quantity of powdered charcoal, in a ſimilar manner. On triturating the mixture ſtrongly it will inflame, but not with much noiſe.

(c) Mix a ſmall quantity of ſugar with half its weight of the ſalt, and on the mixture pour a little ſtrong ſulphuric acid. A ſudden and vehement inflammation will be produced. This experiment, as well as the following, requires caution.

(d) To one grain of the powdered ſalt in a mortar, add about half a grain of phoſphorus. The phoſphorus will detonate on the gentleſt triture, with a very loud report. The hand ſhould be covered with a glove in making this experiment, and care ſhould be taken that the phoſphorus, in an inflamed ſtate, does not fly into the eyes.

(e) Oxygenated muriate may be ſubſtituted for nitre in the preparation of gunpowder; but the mixture of the ingredients requires great circumſpection. It may be proper, alſo, to ſtate, that this ſalt ſhould not be kept mixed with ſulphur in conſiderable quantity, ſuch mixtures having been known to detonate ſpontaneouſly.

Oxygenated Muriate of Soda.

This salt has no remarkable properties. It differs from the combination of this acid with pot-aſh, in attracting moiſture from the atmoſphere.

With ammonia, the oxygenated muriatic acid does not afford any combination; but decompoſes this alkali, when brought into contact with it, whether in a gaſſeous or liquid ſtate. Weſtrumb has even aſſerted, that when liquid ammonia is poured into a veſſel filled with oxygenated muriatic gas, an inflammation enſues. This appearance, however, I could never produce. The decompoſition of ammonia, by oxygenated muriatic acid, is beſt exhibited, by paſſing the gas through a bottle filled with a watery ſolution of ammonia, and having two openings, from one of which a bent tube paſſes to the pneumato-chemical apparatus, while the other receives the tube that brings the acid gas. The gas, that is produced, will be found to be azotic. The theory of this decompoſition will be explained on a ſubſequent occaſion.

This property of ammonia renders it extremely uſeful in correcting the offenſive vapours of the gas, which are ſometimes accidentally ſet at liberty, in places where it is prepared. And when ſuffocation threatens to come on, in conſequence of the fumes of this acid, the moſt effectual remedy is to hold a ſtopper, moiſtened with ammonia, to the mouth and noſtrils.

Nitro-Muriatic Acid.

This acid is a compound of the nitric and muriatic acid, and may be formed by mixing two parts of nitric acid with one of muriatic, and by ſeveral other proceſſes, which are pointed out in every elementary book. Its moſt diſtinguiſhing property, that of diſſolving gold, will be deſcribed hereafter.

ART. XV. *Phoſphorus—Phoſphoric Acid—Phoſphates.*

1. *Phoſphorus is an inflammable ſubſtance, and is known by the following characters.*

A. It has generally a fleſh red colour; but when carefully purified, may be obtained as free from colour, and as tranſparent, as melted white wax.

B. It is ſo ſoft that it readily yields to the knife.

C. It melts with a very gentle heat. To ſhew this, it muſt be covered with water, to prevent it from in-
ming.

D. In the atmoſphere, it emits a white ſmoke, and peculiar ſmell; and a faint and beautiful light ariſes from it.

2. *Phoſphorus is inflamed by the application of a very gentle heat.* According to Dr. Higgins, a temperature of 60° is ſufficient to ſet it on fire, when perfectly dry. It burns with a very brilliant light, a white ſmoke, and a ſuffocating ſmell.

3. *It may be ſet on fire by friction.* Rub a very ſmall bit between two pieces of brown paper; the phoſphorus will inflame, and will ſet the paper on fire alſo.

4. *In oxygenous gas it burns with a very beautiful light*; and alſo in nitrous oxyd, and in oxygenated muriatic acid.

5. *Phoſphorous is volatile.* Hence it may be raiſed by diſtillation; but to prevent its taking fire on the application of heat, the retort ſhould previouſly be filled with azotic or hydrogen gas, and the mouth of the retort must be immerſed in water. By diſtillation in this mode, phoſphorus is rendered much purer.

6. *Phoſphorus may be oxygenated in various modes.*

A. By mere expoſure to atmoſpheric air. Let a ſtick of phoſphorus be placed in a funnel, the pipe of which terminates in an empty bottle. The phoſphorus will be ſlowly oxygenated, and after ſome time will be wholly changed into an acid, which will fall into the bottle in a liquid ſtate.

B. By combuſtion in oxygenous gas or atmoſpheric air. When burnt in this manner, every hundred parts of phoſphorus, according to Lavoiſier, gain an addition of 154. See the account of this experiment, in the 5th chapter of his elements.

C. By the nitric acid. If phoſphorus be added by little at once to nitric acid, the nitric acid is decompoſed, and its oxygen, uniting with the phoſphorus, conſtitutes phoſphoric acid,

D. A ſimilar effect is produced by oxygenated muriatic acid in a liquid ſtate. The operation of this acid, in a gaſeous form, is deſcribed, page 79. E.

Accordingly as the phoſphoric acid is differently prepared, its degree of oxygenation differs; and its properties are found to vary proportionably. That formed by the ſpontaneous oxygenation of phoſphorus in air, is termed phoſphoreous acid, as being oxygenated in an inferior degree; and its compounds are called phoſphites; but theſe laſt, it may be obſerved, can ſcarcely be obtained, becauſe the phoſphoreous acid, when combined with alkalis, acquires an addition of oxygen during evaporation.

Phoſphoric Acid.

This acid may be obtained from bones, by proceſſes detailed in every elementary book.

A. *It exiſts in a ſolid ſtate*, in which it may be obtained by evaporation, and fuſion in a crucible. The product has the hardneſs and tranſparency of glaſs.

B. *It is not volatile, nor capable of being decompoſed by heat only.*

C. *When diſtilled in an earthen retort with powdered charcoal it is decompoſed*; its oxygen uniting with the carbon, forms carbonic acid, and the phoſphorous riſes in a ſeparate ſtate. This is the uſual and beſt mode of obtaining phoſphorus.

D. *Phoſphoric acid unites with the different alkalis, and forms a claſs of ſalts termed phoſphates*—of theſe the phoſphate of ſoda is the moſt important one, ſince its introduction into medicine by Dr. Pearſon; and the phoſphate of ammonia is occaſionally uſed as a flux for the blow-pipe.

Another combination of phoſphorus, the properties of which render it a fit ſubject of amuſing experiments, is the

Phoſphorated Hydrogenous Gas.

A. *This Gas may be procured*, by boiling in a retort, phoſphorus with a ſolution of pure pot-aſh. The water is decompoſed; its oxygen uniting with the phoſphorus, forms phoſphoric acid, which combines with the alkali; while the hydrogen diſſolves another portion of phoſphorus, conſtituting phoſphorated hydrogen gas. In preparing this gas, the body of the retort ſhould be filled, as nearly as poſſible, with the alkaline ſolution, otherwiſe the gas, when produced, will inflame and diminiſh the air within the retort, and the water will aſcend from the trough.

2. The properties of this Gas are the following.

A. *It takes fire immediately on coming into contact with the air.* This may be ſhewn by letting it eſcape into the air as it iſſues from the retort, when a very beautiful appearance will enſue.

B. *When mixed ſuddenly with oxygen gas, it detonates.*— This experiment ſhould be made cautiouſly.

C. *The ſame phenomenon enſues on mixing it with oxygenated muriatic acid gas, or with nitrous oxyd.*

Phoſphorus is alſo ſoluble in oils; and when thus diſſolved, forms what has been called liquid phoſphorus, which may be rubbed on the face and hands without injury. It diſſolves, too, in ether; and a very beautiful experiment conſiſts in pouring this phoſphoric ether in ſmall portions, and in a dark place, on the ſurface of hot water.

The phoſphoric matches conſiſt of phoſphorus extremely dry, minutely divided, and perhaps a little oxydated. The ſimpleſt mode of making them is to put a little phoſphorus, dried by blotting paper, into a ſmall phial; heat the phial, and when the phoſphorus is melted, turn it round, ſo that it may adhere to the ſides. Cork the phial cloſely, and it is prepared. On putting a common ſulphur match into the bottle, and ſtirring it about, the phoſphorus will adhere to the match; and will take fire when brought out into the air.

of freſh burnt lime, of the ſize of ſplit peas. Stop the mouth of the tube looſely with a little paper, in order to prevent the free acceſs of air. Next, heat to redneſs that part of the tube which is coated with clay, by means of ſome charcoal; and, when the lime may be ſuppoſed to be red hot, apply heat to the part containing the phoſphorus ſo as to ſublime it, and to bring the vapour of it into contact with the heated lime. The lime and phoſphorus will unite, and will afford a compound of a reddiſh brown colour. This phoſphuret of lime has the remarkable property of decompoſing water, at the common temperature of the atmoſphere. Drop a ſmall piece of it into a wine glaſs of water, and in a ſhort time bubbles of phoſphorated hydrogen gas will be produced; which, riſing to the ſurface, will take fire and explode. If the phoſphuret of lime be not perfectly freſh, it may be proper to warm the water, to which it is added.

4. *Relation to acids.*

A. Lime has a ſtrong attraction for *carbonic acid*, but not when perfectly dry. (a) If a piece of dry quicklime be paſſed into a jar of carbonic acid gas over mercury, no abſorption enſues. But invert a bottle, filled with carbonic acid gas over a mixture of lime and water, of the conſiſtence of cream; and a rapid abſorption will be obſerved, eſpecially if agitated.

(b) Let a jar or bottle, filled with carbonic acid, be brought over a veſſel of lime water.—On agitating the veſſel, a rapid diminution will enſue, and the lime water will become milky.

(c) Leave a ſhallow veſſel of lime water expoſed to the air. A white cruſt will form on the ſurface; and this, if broken, will fall to the bottom, and be ſucceeded by another. This is owing to the abſorption of carbonic acid gas from the air, by the lime, which is thus rendered inſoluble in water.

(d) Lime, when expoſed to the atmoſphere, firſt acquires moiſture, and then carbonic acid; and in a ſufficient ſpace of time, all the characters diſtinguiſhing it as lime diſappear.

(e) Lime has an extremely ſtrong affinity for carbonic acid, which enables it to take this acid from other ſubſtances. Thus carbonates of alkalis are decompoſed by lime. Slake a given quantity of lime into a paſte with water, and add an equal weight of carbonate of pot-aſh or ſoda. Stir the materials together and waſh off the ſoluble part. The carbonic acid combines with the lime, and the alkali is obtained, in a ſtate of ſolution, perfectly free from carbonic acid. This is the ordinary mode of depriving the alkalis of carbonic acid.

(f) Lime, when ſaturated with carbonic acid, forms carbonate of lime. Of this common chalk may be taken as a fair ſample; and in all ſaturated carbonates of this earth, we find the characters of inſipidity and inſolubility in water.

(g) Carbonate of lime is decompoſed by a ſtrong heat. If diſtilled in an earthen retort, carbonic acid gas is obtained, and lime remains in the retort, in a pure or cauſtic ſtate.

(h) It is alſo decompoſed by the ſtronger acids. Put ſome chalk into a gas bottle, and pour on it diluted ſulphuric acid. The ſulphuric acid will unite with the lime, and the carbonic acid will be ſet at liberty.

(i) Carbonate of lime, though ſcarcely diſſolved by pure water, is ſoluble in water ſaturated with carbonic acid. The moſt ſtriking method of ſhewing this is the following. Add to a jar, about one fourth filled with lime water, a very ſmall quantity of water ſaturated with carbonic acid. An immediate milkineſs will enſue, becauſe the carbonic acids forms, with the lime, an inſoluble carbonate. Add gradually more of the water, impregnated with carbonic acid, ſhaking the jar as theſe additions are made. At laſt the precipitate is re-diſſolved. Hence it appears that lime, with a ſmall proportion of carbonic acid, is inſoluble, and, with a ſtill larger, again becomes ſoluble in water.

(k) The carbonate of lime, diſſolved by an exceſs of carbonic acid, is again ſeparated, when this exceſs is driven off. Thus, boiling, which expels the ſuperabundant acid, precipitates the carbonate. Cauſtic or pure alkalis, alſo, produce a ſimilar effect.

B. Combination of lime with *ſulphuric acid*, or ſulphate of lime.

(a) The ſulphuric acid expels the carbonic from lime, and we obtain a ſulphate of lime.

(b) This ſubſtance is very inſoluble, requiring 500 parts of water, at the ordinary temperature, for ſolution.

(c) It is inſipid and free from ſmell.

(d) It is fuſible by a gentle heat.

(e) It is decompoſed, when boiled with a ſolution of carbonate of alkali, a double exchange of principles enſuing.

C. Combination of lime with *nitric acid*. This compound forms a deliqueſcent ſalt, of little importance.

D. Combination with *muriatic acid*.

(a) Lime may be brought into union with muriatic acid, by diſſolving, in the liquid acid, either the pure earth or the carbonate.

(b) The muriate of lime may, alſo, be formed, by boiling together, in a retort, the muriate of ammonia, and lime with water. The lime ſets the alkali at liberty, which may be collected in a liquid form in a receiver, and the muriate of lime remains in the retort.

Or it may be obtained from muriate of ammonia and carbonate of lime, in which caſe we obtain the carbonate of ammonia. For this purpoſe, powdered ſal ammoniac, and dry carbonate of lime, may be mixed together, and put into a glaſs or earthen retort with a long neck. This neck may terminate in a large glaſs globe, which ſhould be kept cool by moiſtened cloth. The carbonate of ammonia will paſs over in a ſolid ſorm, and will condenſe on the inner ſurface of the globe.

(c) Muriate of lime, when evaporated to the conſiſtence of a thick ſyrup, forms, on cooling, an imperfectly cryſtallized maſs, which may be powdered, and reſerved for uſe.

(d) It powerfully attracts moiſture from the air, and hence ſhould be kept cloſely ſtopped up.—Like all other deliqueſcent ſalts, it is very ſoluble in water.

(e) The moſt remarkable property of this ſalt is its power of generating intenſe cold, when mixed with ſnow. This property was diſcovered ſome years ago by M. Lovitz, of St. Peterſburgh; and has been ſince applied in this country, to the congelation of mercury on a very extenſive ſcale.—The proportions, which anſwer beſt, are about equal weights of the ſalt finely powdered, and of freſh fallen and light ſnow. On mixing theſe together, and immerſing a thermometer in the mixture, the mercury ſinks with great rapidity. For meaſuring exactly the cold produced, a ſpirit thermometer ſhould be employed. A few pounds of the ſalt are ſufficient to congeal a large maſs of mercury. By means of 13 lbs of the muriate, and an equal weight of ſnow, Meſſrs. Pepys and Allen froze 56 lbs of quickſilver into a ſolid maſs. The mixture of the whole quantity of ſalt and ſnow, however, was not made at once; but part was expended in cooling the materials themſelves.

On a ſmall ſcale, it may be ſufficient to employ 2 or 3 pounds of the ſalt. Let the mercury, in a very thin glaſs retort, be immerſed firſt in a mixture of one pound of each; and when this has ceaſed to act, let another mixture be prepared. The ſecond will never fail to congeal the quickſilver.

The ſalt, thus expended, may be again evaporated, and cryſtallized for future experiments.

The reader, who wiſhes for further particulars reſpecting theſe experiments, is referred to the Philoſophical Magazine, vol. 3. p. 76.

E. Lime unites with the *phoſphoric acid.*

The phoſphate of lime forms a large part of animal bones, which, to obtain their earthy part, muſt be burnt till perfectly white.

The phoſphate of lime is an inſipid, and inſoluble ſalt, or rather earth. It is decompoſed by ſulphuric acid, which ſets the phoſphoric at liberty. This is the common mode of procuring phoſphoric acid from bones.

F. *Fluate* of lime. This is, alſo, an extremely inſoluble compound. The fluor ſpar, found in Derbyſhire and other places, is the only known ſource of it.—Sulphuric acid decompoſes the fluate, and when diſtilled with this acid, the fluoric acid riſes, and may be collected in a leaden receiver.

This acid, when perfectly pure, ſubſiſts in the ſtate of a gas, condenſible by water. It is the only acid that acts on ſiliceous earth, and on glaſs; and owing to the latter property; it may be employed as a mean of etching on glaſs, as copper is engraved by the nitric acid. See Wilſon's paper in Nicholſon's Journal, vol. 2, p. 60.

Magneſia.

1. *Pure magneſia is white; perfectly taſteleſs; inſoluble in water; and excites no heat when mixed with water.*

2. When expoſed to *carbonic acid gas* with the addition of a little water, the gas is abſorbed, but much more ſlowly than by lime.

Carbonate of magneſia effervesces with acids, its carbonic acid being expelled. When expoſed to heat, its carbonic acid is alſo ſeparated, and the magneſia remains pure. In this ſtate it is termed *calcined magneſia.*

Carbonic acid having a ſtronger affinity for lime, than for magneſia, when carbonate of magneſia is digeſted with lime water, the lime attracts the carbonic acid from the magneſia, and is rendered inſoluble.— Hence the taſte of lime water is totally deſtroyed by carbonate of magneſia.

3. *Magneſia combines with ſulphuric acid.* When concentrated ſulphuric acid is poured on pure magneſia, a great degree of heat is produced; and when the two ingredients are perfectly pure, ignition even enſues.

The combination of magneſia with ſulphuric acid affords a neutral ſalt, termed *ſulphate of magneſia*. This ſalt forms ſmall cryſtals, which have a cool bitter taſte, and diſſolve readily in water. It is decompoſed by pure and carbonated alkalis. If a ſolution of a pound of the ſalt, in a pound of boiling water, be mixed, ſuddenly, with a ſolution of an equal quantity of carbonate of pot-aſh, in the ſame weight of water, a double decompoſition enſues; and the two fluids inſtantly form a thick ſolid coagulum. This, when well waſhed with boiling water, affords the carbonate of magneſia.

The compounds of magneſia with other acids have no properties, that render it neceſſary to deſcribe them in this place.

Alumine, or Argil.

1. *Pure alumine may be obtained* by precipitating a ſolution of alum in water, by the cryſtallized carbonate of pot-aſh. To ſecure its complete purification from ſulphuric acid, Guyton adviſes, that the precipitate be re-diſſolved in nitric acid; that nitrate of barytes be cautiouſly added to the ſolution, till it no longer occaſions milkineſs; and that the alumine be afterwards precipitated, or ſeparated from the nitric acid by heat. (Ann. de Chim. xxxii. 64.)

2. *Alumine has the following qualities.* It adheres to the tongue; when moiſtened with water, it forms a

coheſive maſs; and when heated to redneſs, it ſhrinks conſiderably in bulk, and becomes very hard. It diſſolves ſlowly in all acids. The only combination of importance, is that which it forms with the ſulphuric acid.

3. *With ſulphuric acid it affords ſulphate of alumine, or alum.*

Sulphate of alumine is diſtinguiſhed by the following characters.

A. It has a ſweetiſh aſtringent taſte.

B. It diſſolves in water, 5 parts of which, at 60°, take up one of the ſalt, but hot water diſſolves it in greater abundance.

C. This ſolution reddens vegetable blue colours; which proves the acid to be in exceſs.

D. When mixed with a ſolution of carbonate of potaſh, an effervescence is produced by the uncombined acid, which, alſo, prevents the firſt portions of alkali, that are added to a ſolution of ſulphate of alumine, from occaſioning any precipitate.

E. On a further addition of alkali, the alumine is precipitated.

F. Sulphate of alumine, when heated, ſwells up; loſes its regular form; and becomes a dry ſpungy maſs.

G. It is decompoſed by charcoal, which combines with the oxygen of the ſulphuric acid, and leaves the ſulphur attached to the alumine. A combination of alumine, ſulphur, and charcoal forms the *pyrophorus of Homberg*. To prepare this, equal parts of powdered alum and brown ſugar are melted over the fire, and are kept ſtirring, till reduced to dryneſs. The mixture is then to be finely powdered, and introduced into a common phial, coated with clay, to which a glaſs tube, open at each end, is luted, to allow the eſcape of the gaſſes that are produced. The phial muſt then be ſet in the fire, ſurrounded by ſand, in a crucible. Gas iſſue from the open end of the tube, and may be ed by a lighted paper. When this ceaſes to eſcape, the crucible may be removed from the fire ; and a little moiſt clay preſſed down upon the open end of the tube, to prevent the acceſs of air to the contents of the phial.

The pyrophorus thus formed, is a black and very light powder, which inſtantly takes fire, when poured out of the bottle into the air ; and inflames ſuddenly in oxygenous gas.

Silex.

1. Siliceous earth, or ſilex, may be obtained, tolerably pure, from flints, by the following proceſs. Procure ſome common gun-flints, and calcine them in a crucible, in a red heat. By this treatment they will become brittle, and eaſily reducible to powder. Mix them, when pulverized, with three or four times their weight of carbonate of pot-aſh, and let the mixture be fuſed in a ſtrong red heat, in a crucible. We ſhall thus obtain a compound of alkali and ſiliceous earth. Diſſolve this in water ; filtre the ſolution ; and add to it diluted ſulphuric or muriatic acid. An immediate precipitation will enſue ; and as long as this continues, add freſh portions of acid. Let the precipitate ſubſide ; pour off the liquor that floats above it ; and waſh the ſediment with hot water, till it comes off taſteleſs—then dry it.

2. Siliceous earth, as thus obtained, has the following qualities.

A. It is perfectly white and taſteleſs.

B. When mixed with water, it does not form a coheſive maſs like alumine ; and has a dry and harſh feel to the fingers.

C. It is not acted on by any acid, except the fluoric.

D. When prepared in the foregoing manner, and very minutely divided, ſilex is ſoluble in a ſolution of pure pot-aſh. In the aggregated ſtate of flints, however, it is perfectly inſoluble in this way, an excellent illuſtration of the principle laid down, Art. 1. No. 3.

excellent and very ſenſible teſts of ſulphuric acid, and of all its combinations. Let a ſingle drop of ſulphuric acid fall into a wine quart of pure diſtilled water: On adding a few drops of one of the foregoing ſolutions of barytes, a precipitation will enſue.

F. Sulphate of barytes is decompoſed by carbonate of pot-aſh. Boil the powdered ſulphate, with a ſolution of twice or three times its weight of carbonate of pot-aſh. The carbonic acid will paſs to the barytes, and the ſulphuric to the pot-aſh.

Strontites.[*]

1. Strontites, in a ſtate of purity, has a cauſtic taſte; changes vegetable blues to green; and unites oil with water.

2. It diſſolves very readily in boiling water; and the ſolution, on cooling, ſhoots into regular cryſtals. Theſe are thin quadrangular plates, ſometimes ſquare, oftener paralellograms; not exceeding in length, and not equalling in breadth, a quarter of an inch. Of theſe cryſtals, one ounce of water at 60° takes up only 25 grains.—When expoſed to heat they undergo the ſame changes as thoſe of barytes.

3. Pure ſtrontites ſtrongly attracts carbonic acid.—This may be ſhewn by experiments ſimilar to thoſe on barytes. Indeed the properties of this earth are ſo ſimilar to thoſe of barytes, that every thing, which has been ſaid of the latter, will apply to ſtrontites.

4. The characteriſtic diſtinctions, between the two earths, are derived from the different forms of cryſtals, and different ſolubility, of the ſalts, afforded by their union with the ſame acid. The ſalts, with baſe of ſtrontites, are always much more ſoluble than barytic ſalts.

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[*] I uſe this name after Dr. Hope, who firſt eſtabliſhed the peculiar nature of this earth, (though before ſuggeſted by Dr. Crawford); and who diſcovered its very intereſting properties in a ſtate of purity, as well as those of barytes. (See his Memoir in the fourth vol. of Edinburgh Tranſactions).

The ſalts of ſtrontites have, alſo, the ſingular property, when diſſolved in alcohol, of tinging its flame a deep blood red colour.

The remaining earths I omit; becauſe they very ſeldom occur, and are not likely to become the ſubjects of experiments to the chemical ſtudent. They may be found enumerated and deſcribed, in Mr. Parkinſon's Chemical Pocket Book.

ART. XVIII. *Metals in general.*

The moſt intereſting quality, general to all the metals, is their relation to oxygen.

1. Some metals are oxydated merely by expoſure to atmoſpherical air, at the ordinary temperature. Such are arſenic and manganeſe.

2. Other metals are oxydated by expoſure to air; but not without a conſiderable increaſe of their temperature. Iron, zinc, copper, tin, &c. for example, when made red hot, loſe their metallic brilliancy; and are converted into oxyds of different colours.

3. Other metals are not oxydated, even by the combined operation of air and of an increaſed temperature; ſuch are gold and platina.

4. But even theſe metals (and all others more readily) are oxydated by acids. Thus the nitro-muriatic and oxygenated muriatic acids firſt oxydate gold, and then diſſolve the oxyd. Iron is oxydated by dilute ſulphuric acid, the metal attracting oxygen from the water; and the oxyd of iron, thus produced, is diſſolved by the acid.

5. All metals, that are oxydated by air, undergo the ſame change, much more readily, in oxygenous gas.

6. Some metals are oxydated by water, both at the ordinary temperature of the air, and in high temperatures. Thus iron filings moiſtened with water, become oxyded, in conſequence of its decompoſition; and

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the vapour of water, paſſed over red hot iron, is rapidly decompoſed, and the iron gains 28 per cent of oxygen. Other metals, as gold, ſilver, &c. are not oxyded by water, in any temperature.

7. All metals, in conſequence of oxydation, acquire weight. This may be ſhewn, by keeping a given weight of iron-wire red hot, for ſome time, in the bowl of a common tobacco-pipe; taking care that duſt or aſhes do not fall into it.

8. Metals retain oxygen, with different degrees of force. Some oxyds, (that of mercury for inſtance) are reduced to a metallic ſtate by heat only; but others (as that of iron) require the addition of ſome ſubſtance, that attracts oxygen more ſtrongly than the metal retains it. Thus, to reduce the oxyd of iron, charcoal muſt be added.

9. Metals are precipitated from acids, by each other, not in the form of oxyds, as they are ſeparated by alkalis, but in a metallic form. Thus when a poliſhed plate of iron is immerſed in a ſolution of ſulphate of copper, the copper appears, on the ſurface of the iron, in the ſtate of a metallic coating. In this caſe, the iron attracts the oxygen from the copper; and, as no metal is ſoluble in an acid, unleſs when combined with oxygen, the copper is precipitated.

Art. xix. *Gold.*

1. Gold may be melted, by a moderate red heat.

2. Pure gold is not oxyded by expoſure to heat, with the acceſs of air.

3. It is not acted on, by ſulphuric, nitric, or muriatic acid, even at the boiling temperature.

4. It is diſſolved, however, by nitro-muriatic acid, and alſo by the oxygenated muriatic acid. A thin ſheet of gold introduced into the latter acid, when in a gaſe[illegible]ate, takes fire and burns.

5. The nitro-muriate of gold gives a purple ſtain to the ſkin, and is ſuſceptible of cryſtallization.

6. It is decompoſed by alkalis. A ſolution of pure ammonia, ſeparates an oxyd of gold; and a portion of ammonia, uniting with the oxyd, forms a compound, which detonates very loudly in a gentle heat, and is termed *fulminating gold*. It may be exploded by laying a little on a ſhovel, and applying a very gentle heat over a fire.

7. The ſolution of gold is, alſo decompoſed, by certain combuſtible bodies, which attract the oxygen from the gold and render it inſoluble. (A) Into a dilute ſolution of gold,* contained in a glaſs jar, put a long narrow ſlip of charcoal, and expoſe the whole to the direct light of the ſun. The gold will be revived, and will appear on the charcoal in a metallic ſtate, exhibiting a very beautiful appearance. The ſame change enſues without light, if the ſolution be expoſed to a temperature of 212°.

B. Moiſten a piece of white taffeta ribband, with the dilute ſolution of gold, and expoſe it to a current of hydrogen gas from iron filings and dilute ſulphuric acid. The gold will be reduced, and the ribband will be gilt with the metal. By means of a camel's hair pencil, the gold may be ſo applied as to exhibit regular figures, when reduced.

C. The ſame experiment may be repeated, ſubſtituting phoſphorated hydrogen for common hydrogen gas. The reader who wiſhes for a detail of various experiments of a ſimilar kind, may conſult an Eſſay on Combuſtion, by Mrs Fulhame, publiſhed by Johnſon, London, 1794; and alſo Count Rumford's paper, in the Phil. Trans. 1798, p. 449.

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* The nitro-muriate of gold, employed in theſe experiments, ſhould be previouſly evaporated to dryneſs, in order to expel the ſuperfluous acid, and afterwards diſſolved in diſtilled water.

8. When a ſheet of tin is immerſed in a ſolution of nitro-muriate of gold, the oxyd of gold is precipitated of a purple colour, and when ſcraped off and collected, forms the purple powder of Caſſius, much employed in enamelling. The ſame precipitate is obtained by mixing a ſolution of gold with a ſolution of tin in muriatic acid.

9. Gold is precipitated from its ſolvent by ether; but the oxyd of gold is inſtantly re-diſſolved by the ether; and forms the ethereal ſolution of gold.

10. Sulphurets of alkalis unite with gold both in the dry and humid way. To exhibit this, ſome leaf gold may be digeſted, with heat, in a ſolution of ſulphuret of pot-aſh.

ART. XX. *Platina.*

1. Platina is a white metal, reſembling ſilver in colour, but greatly exceeding it, and indeed all other metals, in ſpecific gravity.

2. It is, of all metals, the moſt difficult of fuſion. It may be melted, however, by a blow pipe, with the aid of oxygenous gas.

3. It is not oxyded when expoſed, red hot, to the air, for a conſiderable length of time.

4. It diſſolves in no acid, except the nitro-muriatic and oxygenated muriatic acids.

5. Theſe ſolutions are decompoſed by alkalis and, alſo, by a ſolution of muriate of ammonia, which laſt has no effect on ſolutions of gold.

ART. XXI. *Silver.*

1. Silver, alſo, is a metal, which is difficultly oxyded by the concurrence of heat and air.

2. It is acted on by ſulphuric acid, which when aſſiſted by heat, oxydates, and partly diſſolves it.

3. Nitric acid, diſſolves it with a diſengagement of nitrous gas; and the ſolution, when evaporated, ſhoots

into regular cryſtals. If the ſilver be pure, the ſolution is colourleſs, otherwiſe it has a green hue.

4. Muriatic acid does not act on ſilver. Yet this acid takes ſilver from others. Thus when muriatic acid is added to nitrate of ſilver, a white curdy precipitate falls down, in great abundance. This precipitate is decompoſed by light; for when expoſed to the direct rays of the ſun, its colour becomes gradually darker. If fuſed by a gentle heat, it forms a ſemi tranſparent maſs of the conſiſtence of horn, called luna cornea, or horn ſilver.

5. A ſolution of nitrate of ſilver ſtains animal ſubſtances a deep black. Hence it has been applied to the ſtaining of human hair; but when thus employed, it ſhould be very much diluted, and uſed with great caution, on account of its corroſive quality.

6. The ſolution of nitrate of ſilver, when evaporated, forms regular cryſtals. Theſe cryſtals fuſe, when heated; and being poured, in this ſtate, into moulds, form the common lunar cauſtic.

7. Nitrate of ſilver is decompoſed by other metals. Thus the ſurface of a plate of copper, to which a little of the ſolution is applied, becomes plated over with ſilver. If a little mercury be poured into a bottle filled with this ſolution, and the bottle be left ſome time undiſturbed, the ſilver is precipitated in a beautiful form, reſembling the branches of a tree, and which has been termed *Arbor Dianæ*. (See Nicholſon's Chemiſtry, p. 249.)

8. Precipitate nitrate of ſilver by lime water; and waſh and dry the precipitate. Let this be afterward put into a veſſel of liquid ammonia. It will then aſſume the form of a black powder, from which the fluid is to be decanted, and the black ſubſtance left to dry in the air. This is the celebrated compound termed *fulminating ſilver*, which detonates with the gentleſt heat, and even with the ſlighteſt friction. When once prepared, no attempt muſt be made to encloſe it in a bot-

ART. XXIV. *Copper.*

1. Copper is oxydated by air. This may be ſhown by heating one end of a poliſhed bar of copper, which will exhibit various ſhades of colour, according to the force of the heat.

2. Copper does not decompoſe water, even with the aſſiſtance of heat.

3. It combines with ſtrong ſulphuric acid, in a boiling heat, and affords a blue ſalt called ſulphate of copper. (A) Sulphate of copper is a regularly cryſtallized ſalt, eaſily diſſolved by water. (B) The ſolution is decompoſed by pure and carbonated alkalis. The former however re-diſſolve the precipitate. Thus, on adding pure liquid ammonia to a ſolution of ſulphate of copper, a precipitate appears, which, on a farther addition of the alkali, is re-diſſolved, and affords a beautiful bright.blue ſolution. (C) The ſulphate of copper is decompoſed by iron. In a ſolution of this ſalt immerſe a poliſhed plate of iron. The iron will ſoon acquire a covering of copper in a metallic ſtate.

4. Copper diſſolves readily in nitric acid, with a diſengagement of nitrous gas. The ſalt, reſulting from this combination, has the ſingular property of detonating with tin.

5. Copper is ſoluble in muriatic acid, with the aid of heat.

6. When corroded by vinegar, it forms verdigriſe.

7. Copper combines with ſulphur. A mixture of three parts of copper filings, and one part of ſulphur, when melted in a glaſs tube, exhibits a combuſtion, more brilliant than that of iron and ſulphur.

ART. XXV. *Lead.*

1. Lead, when melted, and expoſed to the action of the air, becomes covered with a pellicle of oxyd. By long continued expoſure to heat, it is converted into oxyds of different colours. This oxydation it is diffi-

cult to exhibit on a ſmall ſcale. The oxyds of lead may, therefore, be examined as they are found in the ſhops, in the ſtates of minium or red lead; maſſicot; and litharge.

2. The oxyds of lead give up their oxygen, on the application of heat. When diſtilled in an earthen retort, they afford oxygenous gas; and ſtill more readily, when diſtilled with the ſulphuric acid.

3. Of all the acids, the nitric acts moſt ſtrongly on lead, nitrous gas being diſengaged during the ſolution.

4. The muriatic and ſulphuric acids decompoſe nitrate of lead, and form a difficultly soluble muriate and sulphate.

5. The oxyds of lead decompoſe muriate of soda. Mix two parts of finely powdered red lead with one of common salt; and form the two into a paſte with water, adding more occaſionally, as the mixture becomes dry. The alkali will be diſengaged, and the muriatic acid will unite with the oxyd of lead. Wash off the alkali; dry the white maſs; and fuſe it in a crucible. It will form the pigment, called mineral or patent yellow.

6. Lead, when expoſed to the vapour of vinegar, is slowly corroded into a white oxyd, or rather carbonate. This, when diſſolved in diſtilled vinegar, and cryſtallized, forms acetite of lead, or ſugar of lead. This acetite of lead, and indeed all the ſoluble salts of lead, are decompoſed by ſulphurated hydrogen gas. Hence characters, written with acetite of lead, become legible on expoſure to ſulphurated hydrogen gas.

ART. XXVI. *Tin.*

The properties of tin muſt be examined in the ſtate of block tin; what is commonly known by the name of tin, being nothing more than iron plates, with a thin covering of this metal.

1. Tin melts on the application of a moderate heat; by a long continuance of which, it is converted into a

grey powder. This powder, when mixed with pure glaſs, forms a white enamel.

2. Tin is not oxyded by expoſure to air with the concurrence of moiſture, a property which is the foundation of its uſe in covering iron.

3. Tin is diſſolved by all the three mineral acids.

4. Tin may be brought to combine with the oxygenated muriatic acid by firſt forming it into amalgam with mercury; triturating this with an equal weight of oxygenated muriate of mercury; and diſtilling the mixture. The reſult is a liquid which emits denſe white fumes, when expoſed to the air, and was formerly termed the fuming liquor of Libavius.

5. Solutions of tin have the property of precipitating the colouring matter of vegetables, a property which will be noticed hereafter.

ART. XXVII. *Zinc.*

1. Zinc is melted by a very gentle heat.

2. It is rapidly oxyded by atmoſpherical air. When thrown into a red hot crucible, it burns with a bright light, and a white oxyd ſublimes.

3. It diſſolves readily in all the mineral acids. With diluted ſulphuric acid, it affords the pureſt hydrogen gas that can be obtained. The ſalt, when evaporated, ſhoots into regular cryſtals, called ſulphate of zinc.

4. It detonates, when mixed with powdered nitre, and projected into a red hot crucible.

ART. XXVIII. *Biſmuth.*

1. The proper ſolvent for biſmuth is the nitric acid.

2. From this ſolution, a white oxyd is precipitated by the mere addition of water. This, when well waſhed, is the pigment called flake white.

3. This oxyd of biſmuth is blackened by ſulphurated hydrogen gas.

4. Biſmuth forms a component of the fuſible mixture

of metals, diſcovered by Sir Iſaac Newton. Melt together in a crucible eight parts of biſmuth, five of lead, and three of tin, or three of bimuth, one of lead, and five of tin. The reſult is a compound, which will be found to melt in a heat leſs than that of boiling water, and which will even fuſe, under the ſurface of hot water.

ART. XXIX. *Arſenic.*

1. Arſenic, as it is to be found in the ſhops, occurs in the ſtate of a white oxyd, from which the metal may be obtained by the following proceſs. Mix two parts of the white oxyd with one part of black flux*, and put them into a crucible. Invert, over this, another crucible; lute the two together, with a little clay and ſand; and apply a red heat to the lower one. The arſenic will be reduced, and will be found lining the inſide of the upper crucible, in a form of metallic brilliancy.

2. Arſenic is oxyded by mere expoſure to the air. It ſoon becomes tarniſhed, and loſes its metallic luſtre.

3. It is volatile. When laid on a heated iron, it evaporates in the form of a white ſmoke, and emits a ſtrong ſmell of garlic.

4. It is acted on by all acids.

5. It gives a white ſtain to copper. Let a little of the metallic arſenic be put between two ſmall plates of copper; bind theſe cloſely together, by iron-wire; and heat them in a fire. The inſide of the copper plates will be ſtained white by the arſenic.

6. The white oxyd of arſenic is ſoluble in water, which diſſolves about $\frac{1}{80}$ of its weight.

7. The oxyd is ſoluble in moſt acids.

8. The oxyd of arſenic, by repeated diſtillation with nitric acid to dryneſs, is converted into an acid, termed

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* Black flux is formed by detonating, in a crucible, one part of nitre with two of cream of tartar.

is effected by the blow pipe, the colour may be deſtroyed by the interior flame, and again be reproduced by the exterior one, or by a ſmall particle of nitre.

8. When powdered manganeſe, and nitre, are mixed together, and thrown into a red hot crucible, the nitric acid is decompoſed; and we obtain a compound of highly oxydated manganeſe with pot-aſh. This compound has the ſingular property of exhibiting different colours, according to the quantity of water that is added to it. A ſmall quantity gives a green ſolution; a further addition changes it to a blue; more ſtill, to purple; and a ſtill larger quantity to a beautiful deep purple. Hence this has been termed the camelion mineral. This property is deſtroyed by a very ſmall quantity of ſulphuret of potaſh.

9. The roſe colour of ſolutions of maganeſe, in ſulphuric and phoſphoric acids, is deſtroyed, by expoſure to the light of the ſun, and reſtored again, when removed into darkneſs. This effect depends on the deoxydation of the metal by the ſun's rays.

ART. XXXII. *Cobalt.*

1. Cobalt may be purchaſed in a metallic form, at a price lower than that of pure ſilver.

2. Cobalt becomes tarniſhed by expoſure to air, but is not eaſily oxydated, to any extent, by the action of heat and air combined.

3. Its beſt ſolvents are the nitric and nitromuriatic acids; and the ſolutions have the ſingular property of forming ſympathetic inks. Characters written with theſe ſolutions are illegible when cold; but, when a gentle heat is applied, they aſſume a beautiful blue or green colour*. This experiment is rendered more amuſing, by drawing the trunk and branches of a tree, in

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* For ſome ingenious ſpeculations on the cauſe of theſe phenomena, conſult Mr. Hatchett's paper on the Carinthian molybdate of lead. Phil. Trans. 1796.

the ordinary manner, and tracing the leaves with a ſolution of cobalt. The tree appears leafleſs, till the paper is heated, when it ſuddenly becomes covered with beautiful foliage.

4. Oxalic acid throws down, from ſolutions of cobalt, a roſe coloured precipitate.

5. Cobalt, when oxyded, forms zaffre, which has the property of giving a deep blue colour to glaſs.

The rarer and newly diſcovered metals, Molybdenite, Uranite, Tellurite, Chrome, &c, I omit; becauſe, owing to their dearneſs and scarcity, they are not likely to become ſubjects of experiment to the chemical ſtudent.

ART. XXXIII. *Nickel.*

This metal may, alſo, be procured in the ſtate of a regulus. Its ſolutions in nitrous and muriatic acids are of a green colour, and are precipitated blue by ammonia, in which the oxyds are, alſo, ſoluble.

ART. XXXIV. *Vegetable Subſtances.*

1. *Vegetable Extract.*

This may be obtained, by evaporating the expreſſed juices of recent vegetables, or their infuſions or decoctions. It has the following properties:

A. It is coheſive; of a browniſh colour; and generally of a bitteriſh taſte.

B. It is ſoluble in cold water, but much more readily in hot. Hence the decoctions of certain ſubſtances, (Peruvian bark for example) become turbid on cooling.

C. It abſorbs moiſture from the atmoſphere.

D. It is ſoluble in alcohol, and in alkalis, but not in acids.

E. When to its ſolution in water, oxygenated muriatic acid is added, a precipitate is thrown down which is not ſoluble, by the ſame agents as the original extract.

2 *Mucilage.*

This ſubſtance in a dry ſtate is commonly known by the name of gum. Gum arabic may be employed as an example.

A. It is brittle, dry, and inſipid.

B. It forms a viſcid ſolution with water.

C. It is not diſſolved by alcohol.

D. Its ſolution in water is precipitated by Goulard's extract of lead.

Beſide this there is another kind of mucilage termed viſcid mucilage, found in etiolated and young plants, and in the ſap of trees, of which it forms a conſiderable part. It may be obtained by boiling the marſhmallow, or quince ſeeds, in water. Its ſolution is more ropy than that of the gum mucilage, and it becomes ſour by expoſure to the air.

3. *Sugar and Oxalic Acid.*

1. Sugar is ſoluble in water, but leſs readily in alcohol.

2. Sugar on the application of heat, ſwells and foams, and a black coal is left.

3 When heated with nitric acid, it is acidified. Put an ounce of white ſugar into a retort, with ſix ounces of nitric acid, and apply a gentle heat. Nitrous gas will be diſengaged in great abundance. When the whole of the ſugar is diſſolved, diſtill off a part of the acid. The remaining liquor will form regular cryſtals, which muſt be again diſſolved in water, and cryſtalized. Lay this ſecond crop of cryſtals on blotting paper to dry. They have the following properties.

A. They are readily ſoluble in water.

C. They are changed into a coal by a red heat.

B. They have all the properties of an acid.

D. They combine with alkalis, and form neutral ſalts.

E. This acid has the property of forming an inſoluble compound with lime. Into a glaſs of lime water, let fall a drop or two of ſolution of acid of ſugar; a white precipitate will immediately fall to the bottom of the veſſel. The oxalic acid even ſeparates lime from its combination with other acids. Hence a precipitation enſues, on dropping oxalic acid into a ſolution of ſulphate or muriate of lime.

4. *Native Vegetable Acids, and Acidula.*

Native vegetable acids are ſuch as are found, ready formed, in plants or their fruits, and require only preſſure, and other ſimple proceſſes, for their extraction.

A. *Citric acid.* This exiſts, in an uncombined ſtate, in the juice of lemons and of limes, or looſely combined with mucilage and extractive matter. It may be obtained in a pure ſtate, by ſaturating lemon juice with powdered chalk. A white precipitate will fall down, compoſed of citric acid and lime. To this, ſulphuric acid, very much diluted, is to be added. The ſulphuric acid will ſeize the lime, and ſet the citric acid at liberty; and, when the ſolution is evaporated ſufficiently low, the citric acid will ſhoot into regular cryſtals.

This acid is readily ſoluble in water; and may be applied to all the purpoſes, for which freſh lemons are uſed.

B. *Gallic acid.* This acid exiſts in the gall-nut. It may be obtained, by expoſing an infuſion of galls in water to the air. A mouldy pellicle will form on the ſurface of the infuſion; and, after ſome months expoſure, ſmall yellow cryſtals will appear on the inſide of the veſſel. Theſe cryſtals, muſt be diſſolved in alcohol, to ſeparate them from other ſubſtances, and the ſolution evaporated to dryneſs.

It may, alſo, be obtained by ſublimation. Pounded galls are to be put into a retort, and heat applied. The gallic acid will riſe, and be condenſed in the neck of the retort in a ſolid form.

The gallic acid requires 24 times its weight of cold water for ſolution, or three parts of boiling water. Alcohol, when cold, diſſolves one fourth, or an equal weight when heated. Theſe ſolutions redden the infuſion of litmus, and ſtrike a deep black with ſolutions of iron.

C. *Malic acid.* This acid exiſts in the juice of apples, gooſberries, and of ſome other fruits, and is found mixed with the citric, and occaſionally with others. It may be obtained by evaporating the juice nearly to dryneſs, and then adding alcohol, which diſſolves the acids, and leaves the mucilage. To this ſolution of citric and malic acids in alcohol, chalk is to be added to ſaturation, and the precipitate to be waſhed with boiling water, which takes up the malate of lime, and leaves the citrate. The ſolution of the malate of lime may then be decompoſed by ſulphuric acid.

The malic acid cannot be chryſtallized, and, in general, forms deliqueſcent ſalts.

D: *Tartareous acid and its combinations.* This acid may be obtained from common cream of tartar, by diſſolving it in boiling water, and adding chalk, as long as any efferveſcence enſues. An inſoluble tartrite of lime falls down, which may be decompoſed, like the citrate of lime, by ſulphuric acid. On evaporating the ſolution, regular cryſtals are obtained.

This acid is readily ſoluble in water. It combines with alkalis. When pot-aſh is exactly ſaturated with it a neutral ſalt is obtained, which diſſolves very readily in water; but on a ſtill further addition of acid, we obtain a ſalt, which requires 20 parts of water for ſolution. This laſt is identical with common cream of tartar, which is a tartrite of pot-aſh, with a conſiderable exceſs of acid; hence has been termed the acidulous tartrite of pot- By adding to this as much alkali, as will ſaturate of acid, it becomes eaſily ſoluble; and by again rendering the acid ſuperabundant, it is again rendered inſoluble.

E. *Benzoic acid.* This may be obtained from a ſubſtance termed gum benjamin, by ſublimation. It exiſts in a ſolid form, and may be procured at the druggiſts' ſhops, under the name of flowers of benjamin. Theſe flowers are manifeſtly acid properties.

F. The oxalic acid is alſo found native, in the juice of ſorrel, forming a ſalt with exceſs of acid, or an acidulum.

5. *Fixed Oils.*

1. Theſe oils are obtained, by preſſure, from certain vegetables, as the olive, the almond, linſeed, &c.

2. As thus obtained, they are generally found combined with mucilage.

3. They do not combine with water, or with alcohol.

4. They unite with alkalis, and form ſoap.

5. Their properties are changed by boiling with metallic oxyds, thoſe of lead for example. The mucilage unites with the oxyd, and the oil is rendered drying, and fit for the uſe of the painter.

6. *Volatile or Eſſential Oils.*

1. Theſe oils have a penetrating ſmell; and an acrid taſte.

2. They are volatilized by a gentle heat.

3. They are ſoluble in alcohol.

4. They do not unite with water. With the intervention of a little ſugar, however, they are combinable, in ſmall proportion, with water.

5. When nitric acid is poured upon theſe oils, eſpecially if it has been previouſly mixed with one fifth or one ſixth of ſulphuric acid, the mixture burſts out into a violent flame. This experiment requires caution, as the inflamed oil is apt to be ſcattered about.

6. Several of them detonate, when rubbed with oxygenated muriate of pot-aſh, and take fire when poured into oxygenated muriatic acid gas.

7. Eſſential oils are thickened by long expoſure to air.

Camphor reſembles the eſſential oils in many properties, but is not inflamed by nitric acid, which converts it into an acid diſtinguiſhed by peculiar properties, and termed the camphoric acid.

7. *Reſins.*

Reſins are the inſpiſſated juices of certain plants, and are obtained, generally, by wounding their bark. Gum copal, or lac, may be taken as an example.

1. They are dry, brittle and inflammable.
2. They diſſolve readily in alcohol, and eſſential oils, but not in water. From their ſolution in alcohol, they are precipitated by water.
3. They are the baſis of cements and varniſhes, and are chiefly uſed in medicine.

Gum reſins are reſins mixed with extractive matter, and are ſoluble partly in alcohol, and partly in water.

8. *Farina or Fecula.*

Common ſtarch may be taken, as an example of farina. It will be found to have the following qualities.

1. It is not ſoluble in water, unleſs when heated to 160°; and if the temperature be raiſed to 180°, the ſolution coagulates.
2. Like ſugar, it is converted, by the action of the nitric acid, into oxalic acid.
3. When diſtilled alone, it yields an acid, termed the pyromucous. This has been lately ſhewn to be identical with vinegar.
4. Farina forms a conſiderable part of wheat and other flour, and of the potatoe. It may be obtained ſe-[illegible] by waſhing with water.

5. It becomes ſour, when expoſed in a moiſt ſtate to the air.

9. *Gluten.*

1. Gluten may be obtained from wheat flour, by kneading it into dough with water, and waſhing off, from this, all the farina, by repeated affuſions of water, working it at the ſame time with the fingers.

2. It is elaſtic, and when drawn out, recovers itſelf ſomething like the elaſtic gum. When ſtrongly heated it ſhrinks, and if diſtilled in a retort, unlike other vegetable ſubſtances, it yields ammonia.

3. When expoſed moiſt to the atmoſphere, it does not turn ſour, but putrifies like animal matter.

4. It is ſoluble in pure alkalis, and precipitable by acids.

10. *Elaſtic Gum or Caoutchouc.*

1. This ſubſtance is Inflammable.

2. It is inſoluble in water.

3. It is imperfectly diſſolved by ſpirit of turpentine.

4. Its only ſolvent is ether; and, when employed for this purpoſe, the ether ſhould be previouſly waſhed. This may be done by ſhaking it in a bottle, half filled with water, and half with ether. The bottle is next to be held inverted, and the water, which is the heavieſt, ſuffered to eſcape. In this way, about half the ether is loſt; and the remainder is conſiderably ſtronger than before. This ſolution may be ſo applied, as to form hollow tubes.

11. *The Woody Fibre.*

1. This forms the baſis of all wood, and is more abundant in proportion as the wood is harder.

2. It is inſoluble in water.

3. When expoſed to heat it affords a peculiar acid, called the pyroligneous, which has been lately proved

identical with the acetous. In the retort, a black ſubſtance remains, which is charcoal.

12. *Colouring Matter.*

The colouring matter exiſts in vegetables, combined with various other principles; and according to the nature of the ſubſtance with which it is combined, it is ſoluble by different menſtrua. It has an affinity for alumine and for oxyd of tin, in conſequence of which theſe ſolutions precipitate infuſions of the colouring principle in water.

1. To a decoction of madder in water, add a ſolution of ſulphate of alumine. The alumine will combine with the colouring matter, and will form a coloured precipitate, or lake.

2. To the ſame decoction add a little of the nitromuriate of tin. The oxyd of tin will detach the colouring matter, and will form an inſoluble precipitate.

3. Similar experiments may be made on an infuſion of cochineal, which, though an animal production, owes its colouring matter, remotely, to a vegetable.

4. On this principle, of its attraction for colouring matter, depends the uſe of alum in dying, its baſis ſerving as an intermedium between the cloth and the colouring principle.

Wax.

1. Wax is readily fuſible, and inflammable.

2. Yellow wax is bleached by oxygenated muriatic acid.

3. Wax is ſoluble in alkalis.

Reſults of the decompoſition of Vegetables.

Vinous fermentation.—The phenomena and reſult of this proceſs ſhould be accurately examined; which may be done with the aid of an apparatus, ſimilar to that deſcribed in Lavoiſier's Elements, part 3.

The properties of alcohol may be exhibited by thoſe of the ſpirit of wine, generally found in the ſhops. Or the ſpirit may be converted into alcohol by adding to it dry carbonate of pot-aſh, as long as this is rendered moiſt by the ſpirit, and afterwards diſtilling off the alcohol with a very gentle heat.

1. Alcohol is conſiderably lighter than water.

2. It unites chemically with water, and caloric is evolved during the combination. A contraction of bulk, alſo, enſues. Hence a pint of water, and a pint of alcohol, after admixture, and when perfectly cold, are found to occupy a leſs bulk than two pints.

3. It is inflammable. During its combuſtion carbonic acid is generated, and a quantity of water, exceeding in weight the original weight of the alcohol. An ingenious apparatus proving this, is figured in Lavoiſier's Elements, plate IX. fig. 5.

4. Alcohol is the beſt ſolvent of reſins, and eſſential oils.

5. By diſtillation with ſuch acids, as readily give up their oxygen, alcohol is changed into ether. Thus equal parts of ſulphuric acid and of alcohol, mixed together very cautiouſly, by adding ſmall portions of acid repeatedly to the alcohol, give, on diſtillation, the liquor termed ether. It may be formed, alſo, by means of the nitric or oxygenated muriatic acids.

Ether.

1, Ether is extremely light; its ſpecific gravity being even conſiderably leſs than that of alcohol.

2. It is not miſcible with water; and, when theſe two fluids are ſhaken together, the ether, on ſtanding, always riſes to the ſurface.

3. It is extremely volatile. A few drops evaporate, almoſt inſtantly, from the palm of the hand.

4. During its evaporation a conſiderable degree of cold is produced. This may be ſhewn by moiſtening,

repeatedly, the bulb of a thermometer with ether, and expoſing it to the air. See alſo Art. II. No. 12.

5. Ether, at the temperature of 104°, exiſts in the ſtate of a gas. This may be ſhewn by filling a jar with water of this temperature, and inverting it in a veſſel of the ſame. Then introduce a little ether, by means of a ſmall glaſs tube, cloſed at one end. The ether will riſe to the top of the jar, and, in its aſcent, will be changed into gas.

6. Ether is changed into a gas, by diminiſhing the weight of the atmoſphere. Into a glaſs tube about ſix inches long, and half an inch diameter, put a tea ſpoonful of ether, and fill up the tube with water. Then, preſſing the thumb on the open end of the tube, place it, inverted, in a jar of water. Let the whole be ſet under the receiver of an air pump, and the air exhauſted. The ether will be changed into gas, which will expel the water entirely from the tube. On re-admitting the air into the receiver, the gas is again condenſed into a liquid form.

7. The gas, produced by the volatilization of ether, is inflammable. Fill a ſmall and very ſtrong vial with oxygen gas, and let fall into it a drop of ether. On contact with the flame of a candle, a loud exploſion will take place.

Acetous Acid.

1. Common vinegar, purified by diſtillation, may be taken as an example of acetous acid.

2. The acetous acid may be concentrated, by expoſure to cold, which congeals the water ſooner than the real acid, and affords a mean of ſeparating it.

3. Acetous acid unites with alkalis, earths, and metallic oxyds.

A. When pot-aſh, ſaturated with this acid, is evaporated to dryneſs, the ſalt aſſumes a black colour. On being re-diſſolved, however, and again evaporated, the ſalt is obtained white, and when fuſed and ſuffered to cool, affords the acetite of pot-aſh.

This ſalt ſtrongly attracts moiſture from the air, and is very ſoluble in water. When expoſed to a pretty ſtrong heat, it is decompoſed; carbonic acid and carbonated hydrogen gaſſes come over; and in the retort there remains a mixture of carbon with carbonate of pot-aſh.

When this ſalt is diſtilled, with half its weight of ſulphuric acid, the vegetable acid is expelled in a very concentrated form, and is then termed—

Acetic Acid.

1. This acid has a very ſtrong taſte, and a moſt pungent ſmell.

2. It is very volatile; and is inflammable when heated, taking fire on the approach of a lighted paper, and burning like alcohol.

3. It unites with alkalis, and the ſolutions, when evaporated, do not become black. Hence it is probable that the change of acetous into acetic acid depends in great meaſure on the ſeparation of carbon.

4. This acid may be obtained from the acetite of copper by diſtillation per ſe.

5. The acetic acid, in the temperature of 38° of Faht. congeals or becomes glacial; and again liquifies at 59°.

6. When diſtilled with alcohol it affords an ether, termed acetic ether.

The acetous acid may be, alſo, combined with oxyds of lead and of copper. Lead corroded into a white oxyd, or rather carbonate, by the fumes of vinegar, forms ceruſe or white lead, which, when diſſolved in diſtilled vinegar, and chryſtallized, conſtitutes the acetite or ſugar of lead. This ſalt is not decompoſed, without the addition of ſulphuric acid. Copper, corroded in a ſimilar manner, affords verdigris, which, when diſſolved in diſtilled vinegar, affords a chryſtallizable ſalt, called acetate of copper. From this the acetic acid may be ſeparated by diſtillation per ſe.

ART. XXXV. *Animal Subſtances.*

1. *Animal Jelly.*

Animal jelly may be extracted from moſt of the ſoft parts of animals, and even from bones, by long continued boiling. It forms the baſis of ſoups, broth, &c. and imparts to theſe their nutritious properties.

It is readily ſoluble in warm water; and congeals, when cold, into a coheſive ſubſtance, which may again be diſſolved by water. It becomes ſour, when expoſed to the influence of the air. When evaporated to dryneſs, it forms portable ſoup, glue, iſinglaſs, &c.

2 *Animal Albumen.*

The white of an egg may be employed, in exhibiting the qualities of animal albumen.

A. Albumen is inſoluble in water, even at the boiling temperature.

B. It is ſoluble in pure alkalis, and is precipitated again by the addition of acids.

C. It is coagulated, by the temperature of 160°, into a ſolid coheſive maſs; and alſo, by acids, oxyds, and alcohol. The coagulum, thus produced, is ſoluble in alkalis only, and during the ſolution ammonia is evolved.

D. On expoſure to air, it paſſes to the putrefactive ſtate.

E. When expoſed to a gentle heat, in a retort, with diluted nitric acid, azotic gas is diſengaged, which proceeds not from the acid, but from the animal matter.

Gluten, or Animal Fibre.

Gluten forms the baſis of the muſcular or fleſhy parts of animals, and remains, combined with albumen, when all the ſoluble parts have been waſhed away by water. It may, alſo be obtained from coagulated blood by laying this on a linen ſtrainer, and pouring on water, till a white fibrous matter alone remains.

1. Gluten is inſoluble in water, except by the long continued heat of a Papin's digeſter.

2. It is ſoluble in acids, and in pure alkalis.

3. With diluted nitric acid, it yields much more azotic gas than any other animal ſubſtance.

4. It differs from albumen, in being coagulated by the mere contact of air, and by a temperature of 120°; and in being inſoluble in cold liquid ammonia. Its ſtructure, alſo, is fibrous; whereas that of albumen is ſmooth and homogeneous.

Animal Oil.

Animal oil differs from the vegetable oils, in being generally ſolid at the temperature of the atmoſphere, but is ſimilar to them in its other properties. Among animal oils, may be ranked butter, tallow, lard, ſuet, ſpermaceti, &c. They all contain a peculiar acid, called the ſebacic acid. This may be obtained, by adding to the oil, when liquefied by heat, finely powdered quicklime; collecting the ſebate of lime; and diſtilling it with ſulphuric acid.

A ſingular inſtance of the production of animal oil from the lean or muſcular part of animals, is preſented by the converſion of muſcle into a ſubſtance ſtrongly reſembling ſpermaceti. To effect this converſion, it is only neceſſary to confine the fleſhy part of an animal, in a box with ſeveral holes in it, under the ſurface of a running ſtream. When thus confined the change takes place ſpontaneouſly in the courſe of a few months. But it may be accompliſhed, much ſooner, by digeſting animal muſcle in strong nitric acid and washing off the acid by water, as ſoon as the change has enſued. The ſpermaceti, thus obtained, may be bleached, by expoſure to the oxygenated muriatic acid gas.

have acquired various impregnations. The readieſt method of judging of the contents of natural waters, is by applying what are termed teſts, or re-agents; i. e. ſubſtances, which, on being added to water, exhibit, by the phenomena they produce, the nature of the ſaline or other ingredients. For example, if on adding infuſion of litmus to any water, its colour is changed to red, we infer, that the water contains an uncombined acid: If this change enſues, even after the water has been boiled, we judge that the acid is a fixed and not a volatile one: And if, on adding the muriated barytes, a precipitate falls down, we ſafely conclude that the peculiar acid, preſent in the water, is either entirely or in part, the ſulphuric acid. I ſhall firſt enumerate the teſts, generally employed in examining waters, and deſcribe their application; and, afterwards, indicate by what particular teſts the ſubſtances, generally found in waters, may be detected.

1. *Infuſion of Litmus—Syrup of Violets, &c.*

As the infuſion of litmus is apt to ſpoil by keeping, I include in the cheſt ſome ſolid litmus. The infuſion is prepared by ſteeping this ſubſtance, firſt bruiſed in a mortar, and tied up in a thin rag, in diſtilled water, which extracts its blue colour.

If the colour of the infuſion tends too much to purple, it may be amended by a drop or two of ſolution of pure ammonia; but of this, no more muſt be added than is barely ſufficient, leſt the delicacy of the teſt ſhould be impaired.

The ſyrup of violets is not eaſily obtained pure. The genuine ſyrup may be diſtinguiſhed from the ſpurious, by a ſulution of corroſive ſublimate, which changes the former to green, while it reddens the latter. When it can be procured genuine, it is an excellent teſt of acids and may be employed in the ſame manner as the infuſion of litmus.

Paper ſtained with the juice of the March violet, or with that of radiſhes, anſwers a ſimilar purpoſe. In ſtaining paper for the purpoſes of a teſt, it muſt be uſed unſized; or if ſized, it muſt previouſly be waſhed with warm water; becauſe the allum, which enters into the compoſition of the ſize, will otherwiſe change the vegetable colour to red.

In the Philoſophical Magazine, Vol. I. p. 180, may be found ſome recipes for other teſt liquors, invented by Mr. Watt.

Infuſion of litmus is a teſt of moſt uncombined acids.

(1) If the water, under examination, redden the unboiled, but not the boiled water; or if the red colour, occaſioned by adding the infuſion to a recent water, return to blue on boiling, we may infer that the acid is a volatile one, and moſt probably the carbonic acid. Sulphurated hydrogen gas, diſſolved in water, alſo reddens litmus, but not after boiling.

(2) To aſcertain whether the change be produced by carbonic acid, or ſulphurated hydrogen, when experiment ſhows that the reddening cauſe is volatile, add a little lime water. This, if carbonic acid be preſent will occaſion a precipitate, which will diſſolve, with effervеſcence, on adding a little muriatic acid. Sulphurated hydrogen may, alſo, be contained in the ſame water, which will be aſcertained by the teſts hereafter to be deſcribed.

(3) Paper tinged with litmus is, alſo, reddened by the preſence of carbonic acid, but regains its blue colour on drying. The mineral and fixed acids redden it permanently. That theſe acids, however, may produce their effect, it is neceſſary that they ſhould be preſent in a ſufficient proportion. (See Kirwan on Mineral Waters, p. 40.)

II. *Infuſion of Litmus reddened by Vinegar—Spirituous Tincture of Brazil Wood—Tincture of Turmeric—and paper ſtained with each of theſe three ſubſtances—Syrup of Violets.*

All theſe different teſts have one and the ſame object.

(1) Infuſion of litmus reddened by vinegar, or litmus paper reddened by vinegar, has its blue colour reſtored by pure alkalis and pure earths, and by carbonated alkalis and earths.

(2) Turmeric paper and tincture are changed to a reddiſh brown by alkalis, whether pure or carbonated, and by pure earths, but not by carbonated earths.

(3) The red infuſion of Brazil wood, and paper ſtained with it, become blue by alkalis and earths, and even by the latter when diſſolved by an exceſs of carbonic acid. In the laſt mentioned caſe, however, the change will either ceaſe to appear, or be much leſs remarkable, when the water has been boiled.

(4) Syrup of violets, when pure is, by the ſame cauſes, turned green; as alſo paper ſtained with the juice of the violet or with radiſhes.

III. *Tincture of Galls.*

Tincture of galls is the teſt generally employed for diſcovering iron, with all the combinations of which it produces a black tinge, more or leſs intenſe according to the quantity of iron. By applying this teſt before and after evaporation or boiling, we may know whether the iron be held in ſolution by carbonic acid, or a fixed acid; for

(1) If it produce its effect before the application of heat and not afterward, carbonic acid is the ſolvent.

(2) If after as well as before, a mineral acid is the ſolvent.

(3) If by the boiling a yellowiſh powder be precipitated, and yet galls continue to ſtrike the water black

afterwards, the iron, as often happens, is diſſolved both by carbonic acid and by a fixed acid.

IV. *Sulphuric Acid.*

(1) Sulphuric acid diſcovers, by a ſlight efferveſcence, the preſence of carbonic acid, whether uncombined, or united with alkalis or earths.

(2) If lime be preſent, whether pure or uncombined, the addition of ſulphuric acid occaſions, after a few days, a white precipitate.

(3) Barytes is precipitated, inſtantly, in the form of a white powder.

(4) Nitrous and muriatic ſalts, on adding ſulphuric acid and applying heat, are decompoſed; and if a ſtopper, moiſtened with ſolution of pure ammonia, be held over the veſſel, white clouds will appear. For diſtinguiſhing whether nitric or muriatic acid be the cauſe of this appearance, rules will be given hereafter.

V. *Nitric and Nitrous Acids.*

Theſe acids, if they occaſion efferveſcence, give the ſame indications as the ſulphuric. The nitrous acid has been recommended, as a teſt diſtinguiſhing between hepatic waters that contain ſulphuret of pot-aſh and thoſe that contain only ſulphurated hydrogen gas. In the former caſe a precipitate enſues on adding nitrous acid, and a very fœtid ſmell ariſes: in the latter a slight cloudiness only appears, and the ſmell of the water becomes leſs diſagreeable.

VI. *Oxalic Acid and Oxalates.*

This acid is a moſt delicate teſt of lime, which it ſeparates from all its combinations.

(1) If a water, which is precipitated by oxalic acid, become milky on adding a watery ſolution of carbonic acid, we may infer that pure lime (or barytes, which has never been yet found pure in waters) is preſent.

(2) If the oxalic acid occaſion a precipitate, before but not after boiling, the lime is diſſolved by an exceſs of carbonic acid;

(3) If after boiling, by a fixed acid. A conſiderable exceſs of any of the mineral acids, however, prevents the oxalic acid from occaſioning a precipitate, even though lime be preſent, becauſe ſome acids decompoſe the oxalic, and others, diſſolving the oxalate of lime, prevent it from appearing. (Vid. Kirwan on Waters, p. 88.)

The oxalate of ammonia, or of pot-aſh, (which may eaſily be formed by ſaturating their reſpective carbonates with a ſolution of oxalic acid) are not liable to the above objection; and are preferable, as re-agents, to the uncombined acid.

The fluate of ammonia, recommended by Scheele, I find to be a moſt delicate teſt of lime. It may be prepared by adding carbonate of ammonia to diluted fluoric acid, obſerving that there be a ſmall exceſs of acid.

VII. *Pure Alkalis, and Carbonated Alkalis.*

(1) The pure fixed alkalis precipitate all earths and metals, whether diſſolved by volatile or fixed menſtrua; but only in certain ſtates of dilution; for example, ſulphate of alumine may be preſent in water, in the proportion of 4 grs. to 500, without being diſcovered by pure fixed alkalis. As the alkalis precipitate ſo many ſubſtances, it is evident, that they cannot afford any very preciſe information, when employed as re-agents. From the colour of the precipitate, as it approaches to a pure white, or recedes from it, an experienced eye will judge, that the precipitated earth contains leſs or more of metallic admixture.

(2) Pure fixed alkalis, alſo, decompoſe all ſalts with baſis of ammonia, which becomes evident by its ſmell, and alſo by the white fumes it exhibits, when a ſtopper, moiſtened with muriatic acid, is brought near.

(3) Carbonates of pot-aſh and ſoda have ſimilar effects.

(4) Pure ammonia precipitates all earthy and metallic ſalts. Beſide this property, it, alſo, imparts a deep blue colour to any liquid that contains copper in a ſtate of ſolution.

(5) Carbonate of ammonia has the ſame properties, except that it does not precipitate magneſia from its combinations. Hence, to aſcertain whether this earth be preſent in any ſolution, add the carbonate of ammonia, till no further precipitation enſues; filtre the liquor; and then add pure ammonia. If any precipitation now occurs, we may infer the preſence of magneſia.

VIII. *Lime-Water.*

As any quantity of lime-water, that can be included in a chemical cheſt, would very ſoon be expended, it will be neceſſary for the experimenter to prepare it himſelf, which may be done according to the proceſs deſcribed in page 86.

(1) Lime water is applied to the purpoſes of a teſt, chiefly for detecting carbonic acid. Let any liquor, ſuppoſed to contain this acid, be mixed with an equal bulk of lime-water. If carbonic acid be preſent, either free or combined, a precipitate will immediately appear, which, on adding a few drops of muriatic acid, will again be diſſolved with effervefcence.

(2) Lime-water will alſo ſhew the preſence of corroſive ſublimate, by a brick-duſt coloured ſediment. If arſenic be contained in a liquid, lime water, when added, will occaſion a precipitate, conſiſting of lime and arſenic, which is very difficultly ſoluble in water. This precipitate, when mixed up with oil and laid on hot coals, yields the well known garlic ſmell of arſenic.

IX. *Pure Barytes, and its Solution in Water.*

(1) A ſolution of pure barytes is even more effectual than lime-water, in detecting the preſence of carbonic

but as of both theſe we have much better indicators, I do not enlarge on its application to this purpoſe.

(2) The acetite is alſo a teſt of ſulphurated hydrogen, and of ſulphurets of alkalis, which occaſion a black precipitate; and if a paper, on which characters are traced with a ſolution of acetite of lead, be held over a portion of water containing ſulphurated hydrogen, they are ſoon rendered viſible.

(3) The acetite of lead is employed in the diſcovery of uncombined boracic acid, a very rare ingredient of waters. To aſcertain whether this be preſent, ſome cautions are neceſſary. (a) The uncombined alkalis and earths (if any be ſuſpected) muſt be ſaturated with acetite or acetous acid. (b) The ſulphates muſt be decompoſed by acetite or nitrate of barytes, and the muriates by acetite or nitrate of ſilver. The filtered liquor, if boracic acid be contained in it, will give a precipitate ſoluble in nitric acid of the ſpecific gravity of 1. 3.

XIV. *Nitrate of Mercury prepared with and without heat.*

This ſolution, differently prepared, is ſometimes employed as a teſt. But ſince other teſts anſwer the ſame purpoſes more effectually, I have not thought proper to include the nitrate of mercury in the cheſt. * For the ſame reaſon, alſo, oxygenated muriate of mercury is omitted.

XV. *Muriate, Nitrate, and Acetite of Barytes.*

(1) Theſe ſolutions are all moſt delicate teſts of ſulphuric acid, and of its combinations, with which they give a white precipitate, inſoluble in dilute muriatic acid. They are decompoſed, however, by carbonates of alkali; but the precipitate, occaſioned by theſe, is ſolu-

[illegible]enry here and in ſome other places, ſpeaks of portable [illegible]es for ſale.

ble in dilute muriatic or nitric acids, with efferveſcence.

(2) Phoſphoric ſalts occaſion a precipitate, alſo, which is ſoluble in muriatic acid, without efferveſcence.

XVI. *Pruſſiates of Pot-aſh, and of Lime.*

Of theſe two, the pruſſiate of pot-aſh is the moſt eligible. When pure, it does not ſpeedily aſſume a blue colour on the addition of acid, nor does it *immediately* precipitate muriated barytes.

Pruſſiate of pot-aſh is a very ſenſible teſt of iron, with whoſe ſolutions in acids, it produces a Pruſſian blue precipitate, in conſequence of a double elective affinity. To render its effect more certain, however, it may be proper to add, previouſly, to any water ſuſpected to contain iron, a little muriatic acid, with a view to the ſaturation of uncombined alkalis or earths, which if preſent, prevent the detection of very minute quantities of iron.

(1) If a water, after boiling and filtration, does not afford a blue precipitate, on the addition of pruſſiate of pot-aſh, the ſolvent of the iron may be inferred to be a volatile one, and probably the carbonic acid.

(2) Should the precipitation enſue in the boiled water, the ſolvent is a fixed acid, the nature of which muſt be aſcertained by other teſts.

The beſt mode of preparing pruſſiate of pot-aſh, in a ſtate of purity, is deſcribed by Mr. W. Henry, in Nicholſon's Journal, vol. 4.

XVII. *Solution of Soap in Alcohol.*

This ſolution may be employed to aſcertain the comparative hardneſs of waters. With diſtilled water it may be mixed, without any change enſuing; but if added to a hard water, it produces a milkineſs, more or leſs conſiderable, as the water is leſs pure; and from the degree of this milkineſs, an experienced eye will derive a tolerable indication of the quality of the water. This effect is owing to the alkali quitting the oil, whenever there is preſent in a water any ſubſtance, for which e alkali has a ſtronger affinity than it has for oil. Thus l uncombined acids, and all earthy and metallic ſalts ecompoſe ſoap; and occaſion that property in waters hich is termed hardneſs.

XVIII. *Alcohol.*

Alcohol, when mixed with any water, in the proortion of about an equal bulk, precipitates all the ſalts, hich it is incapable of diſſolving. (See Kirwan on Vaters, p. 263.)

XIX. *Sulphuret of Ammonia.*

This and other ſulphurets, as well as water ſaturated vith ſulphurated hydrogen, may be employed in detecing lead and arſenic, with the former of which they ive a black, and with the latter a yellowiſh, precipitate. As lead and arſenic, however, are never found in natural waters, I ſhall reſerve, for another occaſion, what I ave to ſay of the application of theſe teſts.

Subſtances that may be expected in Mineral Waters; and the means of detecting them.

Acids in general. Infuſion of litmus—Syrup of violets, I.

Acid Boracic. Acetite of lead, XIII. 3.

Acid Carbonic. Infuſion of litmus, I. 1. 2—Lime water, VIII. 1.—Barytic water IX. 1.

Acid Muriatic. Nitrate and acetite of ſilver, XII.

Acid Nitric. Sulphuric acid, IV. 4.

Acid Phoſphoric. Solutions of barytes, XV. 2.

Acid Sulphureous. By its ſmell—and deſtroying the ur of litmus, and of infuſion of red roſes—by the of the ſmell, a few hours after the addition of xyd of manganeſe.

Acid Sulphuric. Solution of pure barytes, IX. Barytic ſalts, XV. Acetite of lead, XII.

Alkalis in general. Vegetable colours, II.

Ammonia, by its ſmell and teſts, II.

Barytes and its compounds, by ſulphuric acids, IV.

Carbonates in general. Effervеſce on adding acids.

Earths diſſolved by carbonic acid. By a precipitation on boiling—by pure alkalis, VII.

Iron diſſolved by carbonic acid. Tincture of galls, III. 1. Pruſſiate of pot-aſh, XVI. 1.

——————— *by ſulphuric acid.* Same teſts, III. 3. XVI. 2.

Lime in a pure ſtate. Water ſaturated with carbonic acid. Blowing air from the lungs. Oxalic acid, VI.

—————— *diſſolved by carbonic acid.* Precipitation on boiling—Cauſtic alkalis, VII. Oxalic acid, VI.

Magneſia diſſolved by carbonic acid. Precipitation on boiling—the precipitate ſoluble in dilute ſulphuric acid.

Muriates of alkalis. Solutions of ſilver, XII.

—————— *of lime.* Solutions of ſilver, XII. and oxalic acid, VI.

Sulphates in general. Barytic ſolutions, IX. and XV.—Acetite of lead XII.

Sulphate of Alumine. Barytic ſolutions, XI. and XV. —A precipitate by carbonate of ammonia not ſoluble in acetous acid, but ſoluble in pure fixed alkalis by boiling.

Sulphate of lime. Barytic ſolutions IX. and XV.—Oxalic acid, VI.—A precipitate by alkalis not ſoluble dilute ſulphuric acid.

Sulphurets of alkalis. Poliſhed metals, X. Smell on adding ſulphuric or muriatic acid.—Nitrous acid, V.

Sulphurated hydrogen gas. Infuſion of litmus, I. Poliſhed metals, X. Acetite of lead, XIII. 2.

* * *

The reader, who may wiſh for rules for the complete and accurate analyſis of mineral waters, will find in almoſt every elementary work, a chapter allotted to this ſubject. He may, alſo, conſult Bergman's Phyſical and Chemical Eſſays, Vol. I. Eſſay 2d. and Kirwan's Eſſay on the Analyſis of Mineral Waters, London, 1799. As this manual, however, may ſometimes be employed as a travelling companion, and may attend the Chemiſt where more bulky works cannot be had, it may be proper to ſtate, briefly the mode of analyzing waters, by the more certain, but ſtill not unobjectionable, mode of evaporation.

The veſſels, employed for evaporation, ſhould be of ſuch materials, as are not likely to be acted on by the contents of the water. I prefer thoſe of unglazed biſcuit ware, made by Meſſrs. Wedgwoods; but as their ſurface is not perfectly ſmooth, and the dry maſs may adhere ſo ſtrongly as not to be entirely ſcraped off, the water when reduced to about one tenth or leſs, may be transferred, with any depoſit that may have taken place, into a ſmaller veſſel of glaſs. Here, let it be evaporated to dryneſs.

A. The dry maſs, when collected and accurately weighed, is to be put into a bottle, and alcohol poured on it to the depth of an inch. After having ſtood a few hours, and been occaſionally ſhaken, pour the whole
ltre, waſh it with a little more alcohol; and dry
the remainder.

undiſſolved reſidue, and eight times its
d diſtilled water; ſhake the mixture fre-

quently; and, after ſome time, filtre; aſcertaining the loſs of weight.

C. Boil the reſiduum for a quarter of an hour, in ſome what more than 500 times its weight of water, and afterwards filtre.

D. The reſidue, which muſt be dried and weighed, is no longer ſoluble in water or alcohol. If it has a brown colour, denoting the preſence of iron, let it be moiſtened with water, and expoſed to the ſun's rays for ſome weeks.

I. The ſolution in alcohol (A) may contain one or all of the following ſalts—muriates of lime, magneſia, or barytes, or nitrates of the ſame earths. Sometimes, alſo, the alcohol may take up a ſulphate of iron, in which the metal is highly oxydated; as will appear from its reddiſh brown colour.

1. In order to diſcover the quality and quantity of the ingredients, evaporate to dryneſs, add above half its weight of ſtrong ſulphuric acid, and apply a moderate heat. The muriatic or nitric acid will be expelled; and will be known by the colour of their fumes, the former being white, and the latter orange coloured.

2. To aſcertain whether lime or magneſia be the baſis, let the heat be continued, till no more fumes ariſe; and let it then be raiſed, to expel the exceſs of ſulphuric acid. To the dry maſs, add twice its weight of diſtilled water. This will take up the ſulphate of magneſia, and leave the ſulphate of lime. The two ſulphates may be ſeparately decompoſed by boiling with three or four times their weight of carbonate of pot-aſh. The carbonates of lime and magneſia, thus obtained, may be ſeparately diſſolved in muriatic acid and evaporated. The weight of the dry ſalts will inform us, how much of each the alcohol had taken up.

The preſence of barytes, which is very rarely to be expected, may be known by a precipitation enſuing, on adding ſulphuric acid to a portion of the alcohol ſoludeed has never yet been effected. It would lead me into too long a diſcuſſion, to comment, in this place, on the definitions that have been generally offered, and to ſtate the grounds of objection to each of them. Senſible, therefore, that I am unable to preſent an unexceptionable character of earthy bodies, I ſhall ſelect ſuch a one, as may be ſufficient for the leſs accurate purpoſe of general diſtinction.

" The term Earth," ſays Mr. Kirwan, " denotes a taſteleſs, inodorous, dry, brittle, uninflammable ſubſtance, whoſe ſpecific gravity does not exceed 4. 9. (i. e. which is never five times heavier than water), and which gives no tinge to borax in fuſion." After ſtating ſome exceptions to this definition, afforded by the ſtrong taſte of certain earths, and the ſolubility of others, he adds: " Since, however, a line muſt be drawn between ſalts and earths, I think it ſhould begin where ſolution is ſcarce perceptible; ſalts terminating, and earths, in ſtrictneſs, commencing, where the weight of the water, requiſite for the ſolution, exceeds that of the ſolvend, 1000 times. But, not to depart too widely from the commonly received import of words that are in conſtant uſe, ſubſtances, that require 100 times their weight of water to diſſolve them, and have the other ſenſible properties of earths, may be ſo ſtyled in a looſe and popular ſenſe."

The ſimple, or primitive earths, are thoſe which cannot be reſolved into more remote principles. Such are lime, argill, magneſia, &c.

The compound earths are compoſed of two or more primitive earths, united chemically together. Sometimes, the union of an earth with an acid conſtitutes what is vulgarly called an earth, as in the examples of ſulphate of lime, fluate of lime, &c.

Salts. Under this head, Mr. Kirwan arranges " all thoſe ſubſtances, that require leſs than 200 times their weight of water to diſſolve them." This deſcription, though by no means ſo amply characteriſtic of the claſs of ſalts, as to ſerve for an exact definition, is ſufficient for our preſent purpoſe.

"By *Inflammable Foſſils*," the ſame author obſerves, "are to be underſtood all thoſe, of mineral origin, whoſe principal character is inflammability, a criterion, which excludes the diamond and metallic ſubſtances, though, alſo, ſuſceptible of combuſtion."

Metallic Subſtances are ſo well characterized by external properties, as not to require any definition. "Thoſe, on which nature has beſtowed their proper metallic appearance, or which are alloyed only with other metals or ſemi-metals, are called *native* metals. But thoſe that are diſtinguiſhed, as they commonly are in mines, by combination with ſome other unmetallic ſubſtances, are ſaid to be mineralized. The ſubſtance that ſets them in that ſtate is called a mineralizer, and the compound of both an ore." Thus, in the moſt common ore of copper, this metal is found oxydated, and the oxyd combined with ſulphur. The copper may be ſaid to be mineralized by oxygen and ſulphur, and the compound of the three bodies is called an ore of copper.

Method of examining a Mineral, the compoſition of which is unknown.

A mineral ſubſtance preſented to our examination, without any previous knowledge of its compoſition, ſhould firſt be referred to one of the above four claſſes, in order that we may attain a general knowledge of its nature, before proceeding to analyze it minutely.

I. To aſcertain whether the unknown mineral contains ſaline matter, let 100 grains, or any other determinate quantity, in the ſtate of fine powder, be put into a bottle, and ſhaken up repeatedly with 30 times its weight of water, of the temperature of 120 or 130°. After having ſtood an hour or two, pour the contents

2. Let the ſalt in the firſt place, be referred to one of the following orders.

(a) *Acids, or ſalts with exceſs of acid.* Theſe are known by their effect on blue vegetable colours. The particular ſpecies of acid may be diſcovered by the tests deſcribed, page 143.

(b) *Alcalis.* Theſe are characteriſed by their effect on vegetable colours, and by the other properties enumerated, page 47.

(c) *Salts with metallic baſes.* Theſe afford a very copious precipitate, when mixed with a ſolution of pruſiate of pot aſh. To aſcertain the ſpecies of metal, precipitate the whole by pruſſiate of pot-aſh; calcine the precipitate; and proceed according to the rules, which will hereafter be given, for ſeparating metals from each other.

(d) *Salts with earthy baſes.* If a ſolution of ſalt, in which pruſſiate of pot-aſh occaſions no precipitation, afford a precipitate on adding pure or carbonated pot-aſh, we may infer, that a compound of an acid, with ſome one of the earths, is preſent in the ſolution. Or if after pruſſiate of pot aſh has ceaſed to throw down a ſediment, the above mentioned alkali precipitates a further portion, we may infer that both earthy and metallic ſalts are contained in the ſolution. In the firſt caſe, add the alkaline ſolution, and, and when it has ceaſed to produce any effect, let the ſediment ſubſide; decant the ſupernatant liquor; and waſh and dry the precipitate. The earths may be examined, according to the rules that will be given in the following article. In the ſecond caſe, pruſſiate of pot-aſh muſt be added, as long as it precipitates any thing; and the liquor muſt be decanted from the ſediment, which is to be waſhed with diſtilled water, adding the waſhings to what has been poured off. The decanted ſolution muſt next be mixed with the alkaline one, and the precipitated earths reſerved for experiment. By this laſt proceſs, earths and metals may be ſeparated from each other.

E. *Neutral Salts with alkaline baſes.* Theſe ſalts are not precipitated either by pruſſiate or carbonate of pot-aſh. It may happen, however that ſalts of this claſs may be contained in a ſolution, along with metallic or earthy ones. In this caſe the analyſis becomes difficult; becauſe the alkali, that is added to precipitate the two laſt, renders it difficult to aſcertain, whether the neutral ſalts are owing to this addition, or were originally preſent. I am not aware of any method of obviating this difficulty, except the following. Let the metals be precipitated by pruſſiate of ammonia; and the earths by carbonate of ammonia, in a temperature of 180° or upwards, in order to enſure the decompoſition of magneſian ſalts, which this carbonate does not effect in the cold. Separate the liquor by filtration, and boil it to dryneſs. Then expoſe the dry maſs to ſuch a heat, as is ſufficient to expel the ammoniacal ſalts. Thoſe, with baſis of fixed alkali, will remain fixed. By this proceſs, indeed, it will be impoſſible to aſcertain whether ammoniacal ſalts were originally preſent; but this may be learned by adding, to the ſalt under examination, before its ſolution in water, ſome pure pot-aſh, which, if ammonia be contained in the ſalt, will produce its peculiar ſmell. The vegetable and mineral alkalis may be diſtinguiſhed by adding to the ſolution a little tartarous acid, which precipitates the former but not the latter.

Having aſcertained the baſis of the ſalt, the acid will eaſily be diſcriminated. Muriated barytes will indicate ſulphuric acid, nitrate of ſilver the muriatic; and ſalts containing nitric acid may be known by a detonation enſuing on projecting them, mixed with powdered charcoal, into a red hot crucible.

2. *Examination of Earths and Stones.*

When a mineral, the compoſition of which we are deſirous to diſcover, reſiſts the action of water, and poſſeſprecipitation; but after ſome time, ſmall and inſoluble cryſtals will form on the ſurface of the jar. Theſe are the pruſſiated barytes, which may be changed into the carbonate by red heat, continued with the acceſs of air, till the black colour diſappears. The ſtrontites may be afterwards ſeparated from the ſolution by carbonate of pot-aſh.

A third method of ſeparating ſtrontites from barytes is founded on the ſtronger affinity of barytes, than of the former earth, for acids. Hence, if the two earths be preſent in the ſame ſolution, add a ſolution of pure barytes (ſee page 97) till the precipitation ceaſes. The barytes will ſeize the acid, and will throw down the ſtrontites. The ſtrontitic ſolution, in this caſe, ſhould have no exceſs of acid, which would prevent the action of the barytic earth.

D. The ſolution (B) after the addition of ſulphate of ſoda, may contain lime, magneſia, alumine, and ſome metallic oxyds. To ſeparate the oxyds, add pruſſiate of pot-aſh, till its effect ceaſes, and filtre the ſolution, reſerving the precipitate for future experiments.

E. When lime, magneſia, and alumine are contained in the ſame ſolution, proceed as follows.

(a) Precipitate the ſolution, previouſly made hot by carbonatd of pot aſh; waſh the precipitate well, and dry it. It will conſiſt of carbonates of lime, magneſia, and alumine. (b) The alumine may be ſeparated, by digeſtion with a ſolution of pure pot-aſh, which will diſſolve the alumine, but not the other earths. (c) To this ſolution of alumine, add diluted muriatic acid, till the precipitate ceaſes; decant the ſupernatant liquor; waſh the precipitate well with diſtilled water, and dry it. Then expoſe it to a low red heat, in a crucible, and weigh it, which will give the proportion of alumine.

F. Magneſia and lime may be ſeparated, by the following proceſs. Evaporate the ſolution in nitric or muriatic acid to dryneſs. Weigh the dry maſs, and pour on it, in a glaſs evaporating diſh,* more than its own weight of ſtrong ſulphuric acid. Apply a ſand heat till the acid ceaſes to riſe, and then raiſe the heat, ſo as to expel the exceſs of ſulphuric acid. Weigh the dry maſs, and digeſt it in twice its weight of cold diſtilled water. This will diſſolve the ſulphate of magneſia and will leave the ſulphate of lime, which muſt be put on a filtre, waſhed with a little more water, and dried in a low red heat. To eſtimate the quantity of lime deduct from the weight of the ſulphate 59 per cent.

The magneſia is next to be precipitated, from the ſulphate by carbonate of pot-aſh, in a heat approaching 212°; and the precipitate, after being well washed, muſt be dried, and calcined for an hour. Its weight, after calcination, will give the quantity of magneſia contained in the ſtone.

G. If magneſia and alumine only be contained in a ſolution (the abſence of lime being indicated by the non-appearance of a precipitate, on adding oxalate of ammonia) the two earths may be ſeparated by adding, to the cold ſolution, the carbonate of ammonia. This will ſeparate the alumine, which may be collected, waſhed, and dried. The magneſia remaining in ſolution, may be precipitated by carbonate of pot-aſh; heat being applied, to expel the exceſs of carbonic acid.

H. The inſoluble reſidue (A) may contain alumine, ſilex, and oxyds of metals, ſo highly charged with oxygen, as to reſiſt the action of nitric and muriatic acids.

(a) Add concentrated ſulphuric acid, and evaporate the mixture to dryneſs, in the veſſel deſcribed, in the note below. On the dry maſs pour a freſh portion of the acid; boil again to dryneſs; and let this be done, repeatedly, three or four times. By this operation the alumine will be converted into a neutral ſulphate of alumine, which will be rendered eaſily ſoluble in warm water, by adding a ſlight exceſs of acid. Let the ſulphate of alumine be waſhed off, and the inſoluble part be collected and dried. The alumine may be precipitated, by carbonate of pot-aſh; waſhed, dried, and ignited; and its weight aſcertained.

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* The bottom of a broken Florence flaſk anſwers this purpoſe extremely well, and bears without breaking, the heat neceſſary to expel the ſulphuric acid.

(b) The oxyds (generally of iron only) may be ſeparated from the ſilex, in the following manner. Let the inſoluble part (a) be heated in a crucible with a little wax. This will render the oxyds ſoluble in diluted ſulphuric acid; and the ſilex will be left pure and white. Let it be waſhed; ignited; and its weight aſcertained.

2. *Stones inſoluble in diluted nitric and muriatic acids.*

Theſe ſtones muſt be reduced to powder, obſerving the cautions given in page 154.

1. Let 100 grains, or any other determinate quantity, be mixed with three times their weight of pure and dry pot-aſh. Put the whole into a crucible of ſilver or platina, and add a little water. The crucible, covered with a lid, must then be gradually heated; and as the materials ſwell and would boil over, they are to be ſtirred, conſtantly, with a rod of ſilver or platina. When the moiſture is diſſipated, and the maſs has become quite dry, raiſe the heat, as far as can be done without melting the crucible, if of ſilver; and continue the heat, during half an hour or an hour.

The phenomena, that occur during this operation, indicate, in ſome degree, the nature of the mineral under examination. If the mixture undergo a perfectly liquid fuſion, we may preſume that the ſtone contains much ſilicious earth; if it remain paſty and opaque, the other earths are to be ſuſpected; and, laſtly, if it has the form of a dry powder, the bulk of which has conſiderably increaſed, it is a ſign of the predominance of alumine.

If the fuſed maſs has a dark green, or browniſh colour, the preſence of oxyd of iron is announced; a bright green indicates manganeſe, eſpecially if the colour be imparted to water; and a yellowiſh green the oxyd of chrome.

K. The crucible, being removed from the fire, is to be well cleaned on the outſide; and ſet with its contents, in a porcelain or glaſs veſſel, filled with hot water, which is to be ſtirred, and renewed occaſionally, till the whole maſs is detached. The water diſſolves a conſiderable part of the compound of alumine and ſilex with pot-aſh, and even the whole, if added in ſufficient quantity.

L. To the ſolution (K), and the maſs that has reſiſted ſolution, in the ſame veſſel, add muriatic acid. The firſt portions of acid will throw down a flocculent ſediment, which conſiſts of the earths that were held diſſolved by the alkali. Then an efferveſcence enſues; and a precipitate occurs, which is no ſooner formed than it is diſſolved. Laſtly, the portion, that reſiſted the action of water is taken up, ſilently if it contains alumine, and with efferveſcence if it be calcareous earth.

M. From the phenomena, attending the action of muriatic acid, ſome indications may be derived. If the ſolution aſſume a purpliſh red colour, it is a ſign of oxyd of manganeſe; an orange red ſhows iron; and a gold yellow colour betokens chrome. Freedom from colour proves that the ſtone contains no metallic ingredients.

N. When the ſolution is complete, it is to be evaporated to dryneſs in a glaſs veſſel: but if any thing reſiſt ſolution, it muſt be heated as before (I) with pot-aſh. When the liquor approaches to dryneſs, it aſſumes the form of a jelly, and muſt then be diligently ſtirred till quite dry.

O. (a) Let the dry maſs be digeſted in a gentle heat, with three or four pints or even more of diſtilled water; and filtered. (b) Waſh what remains on the filtre, repeatedly; till the waſhings ceaſe to precipitate the nitrate of ſilver; and add the waſhings to the filtered liquor. (c) Let the reſidue on the filtre be dried, and ignited in a crucible. Its weight ſhews the quantity of ſilex. If pure, it ſhould be perfectly white; but if it have any colour, an admixture of ſome metallic oxyd is indicated. From this, it may be purified by digeſtion in muriatic acid; and may again be waſhed, ignited and weighed.

P. The ſolution (O), which owing to the addition of the waſhings, will have conſiderable bulk, is next to be evaporated, till leſs than a pint remains; carbonate of pot-aſh muſt then be added; and the liquor muſt be heated during a few minutes. Let the precipitate, occaſioned by the alkali, ſubſide; decant the liquor from above it; and waſh the ſediment, repeatedly, with warm water. Let it then be put on a filtre and dried.

Q. The dried powder may contain alumine, lime, magneſia, barytes, or ſtrontites; beſides metallic oxyds; which may be ſeparated from each other by the rules already given.

R. It may be proper to examine the ſolution (P) after the addition of carbonate of pot-aſh; in order to diſcover, whether any and what acid was contained in the ſtone.

(a) For this purpoſe, let the exceſs of alkali be neutralized by muriatic acid; and the liquor filtered.

(b) Add to a little of this liquor, a ſolution of muriated barytes. Should a copious precipitate enſue, which is inſoluble in dilute muriatic acid, the preſence of ſulphuric acid is detected. And if much barytes, ſtrontites, or lime, has been found in the precipitate Q we may infer the preſence of a ſulphate of one of theſe three earths.

(c) If, on mixing the liquid (a) with the ſolution of muriated barytes, a precipitate enſues, which is ſoluble, without efferveſcence, in muriatic acid, the phoſphoric acid may be known to be preſent; and if lime be, alſo found, the phoſphate of lime is indicated.

(d) To a portion of the liquor (a) add a ſolution of muriate of lime till the precipitate, if any, ceaſes. Collect this precipitate, waſh it, dry it; and pour on it a little ſulphuric acid. Should acid fumes ariſe, the fluoric acid may be ſuſpected. To aſcertain its preſence deciſively, diſtil a portion of the precipitate with half its weight of ſulphuric acid. The fluoric acid will be known by its effects on the retort, and by the properties deſcribed, page 92.

S. The method of ſeparating, from each other, the metallic oxyds, uſually found as the colouring ingredients of ſtones, remains to be accompliſhed.

(a) Let the precipitate, by the pruſſiate of pot-aſh (D) be expoſed to a red heat; by which the pruſſic acid will be decompoſed. The oxyds, thus obtained, if inſoluble in dilute nitric or muriatic acid, will be rendered ſo by again calcining them with the addition of a little wax or oil.

(b) Or the proceſs may be varied by omitting the precipitation by pruſſiate of pot-aſh, and proceeding as directed, E. page 156

The oxyds will remain mixed with the magneſia and lime; and after the addition of ſulphuric acid, will be held in ſolution by that acid, along with magneſia only.

In both caſes, the ſame method of proceeding may be adopted, ſuch variation only being neceſſary, as is occaſioned by the preſence of magneſia in the latter.

(c) To the ſolution (a or b), containing ſeveral metallic oxyds diſſolved by an acid, add a ſolution of cryſtallized carbonate of pot-aſh, as long as any precipitation enſues. This will ſeparate the oxyds of iron, chrome, and nickel; but the oxyd of mangaueſe, and the magneſia, if any be preſent, will remain diſſolved.

(d) Magneſia, and oxyd of mangaueſe, may be ſeparated, by adding to their ſolution (c) the hydro-ſulphuret of pot-aſh (see p. 67, F), which will throw down the manganeſe, but not the magneſia. The precipitated manganeſe muſt be calcined with the acceſs of air; and weighed. The magneſia may afterwards be ſeparated by ſolution of pure pot-aſh; and when precipitated, muſt be waſhed, dried, and calcined.

(e) The oxyd of chrome may be ſeparated, from thoſe of iron and nickel, by repeatedly boiling the three, to dryneſs, with nitric acid. This will acidify the chrome, and will render it ſoluble in pure pot-aſh, which does not take up the other oxyds. From this combination with pot-aſh the chromic oxyd may be detached, by adding muriatic acid, and evaporating the liquor, till it aſſumes a green colour. Then, on adding a ſolution of pure pot-aſh, the oxyd of chrome will fall down, becauſe the quantity of oxygen, required for its acidification, has been ſeparated by the muriatic acid.

(f) The oxyds of iron and nickel are next to be diſſolved in muriatic acid; and to the ſolution, pure liquid ammonia is to be added, till there is an evident exceſs of it. The oxyd of iron will be precipitated; and muſt be dried and weighed. The oxyd of nickel remains diſſolved by the exceſs of ammonia, to which it imparts a blue colour. It may be ſeparated by evaporating the ſolution to dryneſs, and diſſolving the ſalt.

The analyſis of the stone is now completed, and its accuracy may be judged by the correſpondence of the weight of the component parts, with that of the ſtone, originally ſubmitted to experiment.

It may be proper to obſerve, that certain ſtones, which are not ſoluble in diluted nitrie and muriatic acids, may be decompoſed by an eaſier proceſs than that deſcribed A. Among theſe, are the compounds of barytes, ſtrontites, and lime, with acids, chiefly with the ſulphuric, fluoric, and phoſphoric. The ſulphates of barytes, ſtrontites, and lime; the fluate of lime; and the phoſphate of lime, are all found native in the earth, and, except the laſt, are all inſoluble in the above-mentioned acids. They may be known generally by their external characters. The compounds of barytes and ſtrontites have a ſpecific gravity greater than that of other earths, but inferior to that of metallic ores. They have, frequently a regular or cryſtallized form; are more or leſs tranſparent, have ſome luſtre; and their hardneſs is ſuch as does not prevent their yielding to the knife. The combinations of lime, with the above mentioned acids, are diſtinguiſhed by ſimilar characters, except that they are much leſs heavy. To the mineralogiſt, the outward form and characters of theſe ſtones are ſufficient indications of their compoſition.

Inſtead of the fuſion with alkali, an eaſier proceſs may be recommended. Let the mineral, under examination, be reduced to powder, and be digeſted, in nearly a boiling heat, during one or two hours, with three or four times its weight of carbonate of pot-aſh, and a ſufficient quantity of diſtilled water. The acid, united with the earth, will quit it, and paſs to the pot-aſh; while the carbonic acid will leave the alkali, and combine with the earth. We ſhall obtain, therefore, a compound of the acid of the ſtone with pot-aſh, which will remain in ſolution, while the carbonated earths will form an inſoluble precipitate. The ſolution may be aſſayed, to diſcover the nature of the acid, according to the formula I; and the earths may be ſeparated from each other by the proceſſes B, &c.

T. In the foregoing rules for analyſis, I have omitted the mode of detecting and ſeparating *glucine*; becauſe this earth is of very rare occurrence. When alumine and glucine are preſent in a mineral, they may be ſeparated from the precipitate (E. a.) by pure pot-aſh, which diſſolves both theſe earths. A ſufficient quantity of acid is then to be added to ſaturate the alkali; and carbonate of ammonia is to be poured in till a conſiderable exceſs of this carbonate is manifeſted by the ſmell. The alumine is thus ſeparated; but the glucine, being ſoluble in the carbonate of ammonia, remains diſſolved, and may be precipitated by boiling the ſolution.

U. The preſence of pot aſh (which has lately been diſcovered in ſome ſtones) may be detected by boiling the powdered mineral, repeatedly, to dryneſs, with ſtrong ſulphuric acid. Waſh the dry maſs with water; add a little exceſs of acid; and evaporate the ſolution to a ſmaller bulk. If cryſtals of allum ſhould appear, it is a deciſive proof of pot-aſh, becauſe this ſalt can never be obtained in a cryſtalized form, without the addition of the vegetable alkali.

But, ſince a mineral may contain pot-aſh, and little or no alumine, in which caſe no cryſtals of allum will appear, it may be neceſſary, in the latter caſe, to add a little alumine, along with the ſulphuric acid. Or the ſtone may be ſo hard as to reſiſt the action of ſulphuric acid; and it will then be neceſſary to fuſe it, (in the manner directed I) with ſoda, which has alſo a ſolvent power over alumine and ſilex. The fuſed maſs is to be diſſolved in water; and ſuperſaturated with ſulphuric acid. Evaporate to dryneſs; re-diſſolve in water; and filtre, to ſeparate the ſilex. Evaporate the ſolution, which will firſt afford cryſtals of ſulphate of ſoda, and afterwards, of ſulphate of alumine, ſhould this alkali be contained in the mineral.

The pot-aſh contained in ſulphate of alumine, may be ſeparated from the earth, by adding a ſolution of pure barytes, as long as any precipitation is produced The alumine and ſulphate of barytes will fall down together, and the pot-aſh will remain in ſolution. Its preſence may be known by the teſts, p 146. II. 2.

V. Soda may be detected in a mineral by the following experiments. Let the powdered ſtone be treated with ſulphuric acid, as in U; waſh off the ſolution, and add pure ammonia, till the precipitation ceaſes. Then filtre; evaporate the ſolution to dryneſs; and raiſe the heat ſo as to expel the ſulphate of ammonia. The ſulphate of ſoda will remain, and may be known by the characters, page 64.

III. *Analyſis of Inflammable Foſſils.*

The exact analyſis of inflammable foſſils is ſeldom neceſſary in directing the moſt beneficial application of them. It may be proper however to offer a few general rules for judging of their purity.

I. *Sulphur.* Sulphur ſhould be entirely volatilized, by diſtillation in a glaſs retort. If any thing remain fixed, it muſt be conſidered as an impurity, and may be examined by the preceeding rules.

Sulphur, alſo, ſhould be totally diſſolved by boiling with ſolution of pure pot-aſh, and may be ſeparated from its impurities by this alkali.

2. *Coals.*

1. The proportion of bituminous matter in coal may be learnt by diſtillation in an earthen retort, and collecting the product.

2. The proportion of earthy or metallic ingredients may be found, by burning the coal, with acceſs of air, on a red hot iron. What remains unconſumed muſt be conſidered as an impurity, and may be analyzed by the foregoing rules.

3. The proportion of carbon may be aſcertained, by obſerving the quantity of nitrate of pot-aſh, which a given weight of the coal is capable of decompoſing. For this purpoſe let 500 grains or more of perfectly pure nitre be melted in a crucible, and when red hot, let the coal to be examined, reduced to a coarſe powder, be projected on the nitre, by ſmall portions at once, not exceeding one or two grains. Immediately, when the flame occaſioned by one projection has ceaſed, let another be made; and ſo on till the effect ceaſes. The proportion of carbon in the coal is directly proportionate to the quantity required to alkalize the nitre. Thus ſince

12.709 of carbon are required to alkalize 100 of nitre, it will be eaſy to deduce the quantity of carbon in a given weight of coal, from the quantity of nitre, which it is capable of decompoſing. This method, however, is liable to ſeveral objections, which its inventor, Mr. Kirwan, ſeems fully aware of. See his Elements of Mineralogy, Vol. II. p. 514.

Plumbago, or *Black Lead*, is another inflammable ſubſtance, which it may ſometimes be highly uſeful to be able to identify, and to judge of its purity.—When projected on red hot nitre, it ſhould detonate; and on diſſolving the decompoſed nitre, an oxyd of iron ſhould remain, amounting to one tenth the weight of the plumbago. Any mineral therefore, that anſwers to theſe characters; and leaves a ſhining trace on paper, like that of the black lead pencils, is plumbago.

IV. *Analyſis of Metallic Ores.*

The claſs of metals comprehends ſo great a number of individuals, that it is almoſt impoſſible to offer a comprehenſive formula for the analyſis of ores. Yet ſome general directions are abſoluely neceſſary, to enable the naturaliſt to judge of the compoſitions of bodies of this claſs.

The ores of metals may be analyzed in two modes, in the humid and the dry way. The firſt is effected with the aid of acids and of other liquid agents; and may often be accompliſhed by perſons who are prevented, by the want of furnaces and other neceſſary apparatus, from atempting the ſecond.

It is hardly poſſible to employ a ſolvent capable of taking up all the metals. Thus, the nitric acid does not act on gold or platina; and the nitro-muriatic, which diſſolves theſe metals, has no ſolvent action on ſilver. It will be neceſſary therefore to vary the ſolvent, according to the nature of the ore under examination.

For Ores of Gold and Platina, the nitro-muriatic acid is the moſt proper ſolvent. A given weight of the ore may be digeſted with this acid, as long as it extracts any thing. The ſolution may be evaporated to dryneſs, in order to expel the exceſs of acid; and diſſolved in water. The addition of a ſolution of tin in muriatic acid will ſhew the preſence of gold, by the purple precipitate; and platina will be indicated by a precipitate, on adding a ſolution of muriate of ammonia. When gold and platina are both contained in the ſame ſolution, they may be ſeparated from each other, by the laſt mentioned ſolution, which throws down the platina but not the gold. In this way platina may be detached, alſo from other metals.

When gold is contained in a ſolution, along with ſeveral other metals, it may be ſeparated from moſt of them, by adding a dilute ſolution of ſulphate of iron. The only metals, which the ſalt precipitates, are gold, ſilver and mercury.

For extracting *ſilver* from its ores, the nitric acid is the moſt proper ſolvent. The ſilver may be precipitated by muriate of ſoda (common ſalt). Every hundred parts of the precipitate contain 75 of ſilver. But as lead may be preſent in the ſolution; and this metal is, alſo, precipitated by muriate of ſoda, it may be proper to immerſe in the ſolution (which ſhould not have any exceſs of acid) a poliſhed plate of copper. This will precipitate the ſilver, if preſent, in a metallic form. The muriate of ſilver is alſo ſoluble in liquid ammonia, which that of lead is not.

Copper Ores may be analyzed by boiling them with five times their weight of concentrated ſulphuric acid, till a dry maſs is obtained, from which water will extract the ſulphate of copper. This ſalt is to be decompoſed by a poliſhed plate of iron, immerſed in a dilute ſolution of it. The copper will be precipitated in a metallic ſtate, and may be ſcraped off and weighed.

If ſilver be ſuſpected along with copper, nitrous acid muſt be employed as the ſolvent; and a plate of poliſhed copper will detect the ſilver.

Iron Ores may be diſſolved in dilute muriatic acid, or, if too highly oxydated to be diſſolved by this acid, they muſt be previouſly mixed with one eighth their weight of powdered charcoal, and calcined in a crucible for one hour. The iron is thus rendered ſoluble.

The ſolution muſt then be diluted with 10 or 12 times its quantity of water, previouſly well boiled, to expel the air, and muſt be preſerved in a well ſtopped glaſs bottle, for ſix or eight days. The phoſphate of iron will, within that time, be precipitated, if any be preſent, and the liquor muſt be decanted off.

The ſolution may contain the oxyds of iron, manganeſe, and zinc. It may be precipitated by carbonate of ſoda, which will ſeparate them all. The oxyd of zinc will be taken up, by a ſolution of pure ammonia; diſtilled vinegar will take up the manganeſe; and will leave the oxyd of iron. From the weight of this, after ignition, during a quarter of an hour, 28 per cent. may be deducted. The remainder ſhows the quantity of iron.

Tin Ores. No ſucceſsful mode of analyzing theſe, in the humid way, has hitherto been diſcovered. The preſence of tin in an ore is indicated by a purple precipitate, on mixing its ſolution in muriatic acid, with one of gold in nitro-muriatic acid.

Lead Ores may be analyzed by ſolution in nitric acid, diluted with an equal weight of water. The ſulphur, if any, will remain undiſſolved. Let the ſolution be precipitated by carbonate of ſoda. If any ſilver be preſent, it will be taken up by pure liquid ammonia. Waſh off the exceſs of ammonia by diſtilled water; and add concentrated ſulphuric acid, applying heat, ſo that the muriatic acid may be wholy expelled. Weigh the ſulphate of lead, and after deducting 70 per cent, the remainder shows the quantity of lead.

Mercury may be detected in ores that are ſuppoſed to contain it, by diſtillation in an earthen retort with half their weight of iron filings or lime. The mercury, if any be preſent, will riſe, and be condenſed in the receiver.

Ores of Zinc may be digeſted with the nitric acid, and the part that is diſſolved, boiled to dryneſs; again diſſolved in the acid, and again evaporated. By this means the iron, if any be preſent, will be rendered inſoluble in dilute nitric acid, which will take up the oxyd of zinc. To this ſolution, add pure liquid ammonia in exceſs, which will ſeparate the lead, and iron if any ſhould have been diſſolved; and the exceſs of alkali will retain the oxyd of zinc. This may be ſeparated by the addition of an acid.

Antimonial Ores. Diſſolve a given weight, in three or four parts of muriatic and one of nitric acid. This will take up the antimony, and leave the ſulphur, if any. On dilution with water, the oxyd of antimony is precipitated, and the iron and mercury remain diſſolved. Lead may be detected by ſulphuric acid.

Ores of Arſenic may be digeſted with nitro-muriatic acid, compoſed of one part nitrous, and one and a half or two, of muriatic. Evaporate the ſolution to one fourth; and add water, which will precipitate the arſenic. The iron may afterwards be ſeparated by ammonia.

Ores of Biſmuth are alſo aſſayed, by digeſtion in nitric acid, moderately diluted. The addition of water precipitates the oxyd, and if not wholly ſeparated at firſt, evaporate the ſolution; after which a further addition of water will precipitate the remainder.

Ores of Cobalt may be diſſolved in nitro-muriatic acid. Then add carbonate of pot-aſh, which, at firſt, ſeparates iron and and arſenic. Filtre and add a further quantity of the carbonate, when a greyiſh red precipitate will fall down, which is oxyd of cobalt. The iron and arſenic may be ſeparated by heat, which volatilizes the arſenic. Cobalt is alſo, aſcertained, if the ſolution of an ore in muriatic acid give a ſympathetic ink; ſee p. 116.

Ores of Nickel. Diſſolve them in nitric acid; and add to the ſolution pure ammonia, in ſuch proportion that the alkali may be conſiderably in exceſs. This will precipitate other metals, and will retain the oxyd of nickel in ſolution, which may be obtained by evaporation to dryneſs, and heating the dry maſs, till the nitrate of ammonia has ſublimed.

*Ores of Mangane*ſ*e.* The earths, and ſeveral of the metals, contained in this ore, may firſt be ſeparated by diluted nitric acid, which does not act on highly oxydated manganeſe. The ore may afterward be digeſted with ſtrong muriatic acid which will take up the oxyd of manganeſe. Oxygenated muriatic acid will ariſe, if a gentle heat be applied, and may be known by its peculiar ſmell, and by its diſcharging the colour of wet litmus paper, expoſed to the fumes. From muriatic acid, the manganeſe is precipitated by carbonate of ſoda, in the form of a white oxyd, which becomes black when heated in a crucible. Ores, ſuſpected to contain manganeſe, may alſo be diſtilled per ſe, or with ſulphuric acid, when oxygenous gas will be obtained. Oxyd of manganeſe may be ſeparated from oxyd of iron, by ſolution of pure pot-aſh, which takes up the former but not the latter.

Ores of manganeſe may, alſo, be diſtinguiſhed, by the colour they impart to borax, when expoſed together to the blow pipe. See p. 115.

Ores of Uranite. Theſe may be diſſolved in dilute nitric acid, which takes up the uranitic oxyd, and leaves that of iron; or in dilute ſulphuric acid, which makes the ſame election. Or if any iron has got into the ſolution, it may be precipitated by zinc. Then add cauſtic pot-aſh, which throws down the oxyds of zinc and uranium. The former may be ſeparated by digeſtion in pure ammonia, which leaves, undiſſolved, the oxyd of uranite. This, when diſſolved by dilute ſulphuric acid, affords, on evaporation, cryſtals of a lemon yellow colour.

If copper be preſent, it will be diſſolved, along with the zinc, by the ammonia. If lead, it will form with ſulphuric acid a ſalt much leſs ſoluble than the ſulphate of uranite, and which, on evaporation, will therefore, ſeparate firſt.

Ores of Tungſten. For theſe, the moſt proper treatment ſeems to be digeſtion in nitro-muriatic acid, which takes up the earths, and other metals. The tungſten remains, in the form of a yellow oxyd, diſtinguiſhable by its becoming white on the addition of liquid ammonia, from the oxyd of uranite. To reduce this oxyd to tungſtenite, mix it with an equal weight of dried blood; heat the mixture to redneſs; preſs it into another crucible, which ſhould be nearly full; and apply a violent heat, for an hour at leaſt.

Ores of Molybdena. Repeated diſtillation to dryneſs, with nitric acid, converts the oxyd into an acid; which is inſoluble in nitric acid, and may be thus ſeparated from other metals except iron, from which it may be diſſolved by ſulphuric or muriatic acids. The ſolution in ſulphuric acid is blue when cold, but colourleſs when heated. That in muriatic acid is only blue, when the acid is heated and concentrated.

Analyſis of Ores in the dry way.

To analyze ores in the dry way, a method which affords the moſt ſatisfactory evidence of their compoſition, and ſhould always precede the working of large and expenſive ſtrata, a more complicated apparatus is required

An aſſaying furnace, with muffles, crucibles, &c. are abſolutely neceſſary; but as theſe may be found deſcribed in moſt elementary books, I ſhall omit the detail of them in this place.

The reduction of an ore requires, frequently, previouſly roaſting to expel the ſulphur, and other volatile ingredients. Or this may be effected, by mixing the powdered ore with nitre, and projecting the mixture into a crucible. The ſulphate of pot-aſh thus formed, may be waſhed off; and the oxyd muſt be reſerved for ſubſequent experiments.

As many of the metals retain their oxygen ſo forcibly, that the aplication of heat is incapable of expelling it, the addition of inflammable matter becomes expedient. And to enable the reduced particles of metal to agglutinate and form a collected maſs, inſtead of ſcattered grains, which would otherwiſe happen, ſome fuſible ingredient muſt be added, through which, when in fuſion, the reduced metal may deſcend, and be collected at the bottom of the crucible. Subſtances, that anſwer both theſe purpoſes, are called *fluxes*. The alkaline and earthy part of fluxes ſerve, alſo, another end, viz. that of combining with any acid, which may be attached to a metal, and which would prevent its reduction if not ſeparated.

The ores of different metals, and different ores of the ſame metal, require different fluxes. To offer rules, however, for each individual caſe, would occupy too much room in this work. I ſhall therefore only ſtate a few of theſe fluxes that are moſt generally applicable.

The black flux, (deſcribed page 113 note,) is a very good one. Two parts of muriate of ſoda, previouſly dried in a crucible, one part of powdered lime, one part of fluate of lime, and half a part of charcoal: Or four hundred parts of calcined borax, forty of lime, and fifty of charcoal: Or two parts of pounded glaſs, one of borax, and half a part of charcoal, are all well adapted to the purpoſe of fluxes. The ore, after being roaſted, if neceſſary, is to be well mixed with three or four times its weight of the flux, and put into a crucible, with a little powdered charcoal over the ſurface. A cover muſt be luted on; and the crucible expoſed to the neceſſary heat in a wind furnace. Ores of iron, as being difficultly reduced, require a very intenſe fire. Thoſe of ſilver and lead are metallized by a lower heat.

The volatile metals, as mercury, zinc, and arſenic, it is obvious, ought not to be treated in the above manner, and require to be diſtilled with inflammable matters, in an earthen retort.

For minute inſtructions reſpecting the analyſis of every ſpecies of ore, both in the humid and dry ways, I refer to the ſecond volume of Mr. Kirwan's Mineralogy.

PART III.

Application of Chemical Teſts and Re-agents to various uſeful Purpoſes.

SECTION I.

Method of detecting Poiſons.

WHEN ſudden death is ſuſpected to have been occaſioned by the adminiſtration of poiſons, either wilfully or by accident, the teſtimony of the phyſician is occaſionally required, to confirm or invalidate this ſuſpicion. He may, alſo, be ſometimes called upon to aſcertain the cauſe of the noxious effects, ariſing from the preſence of poiſonous ſubſtances in articles of diet; and it may, therefore, ſerve an important purpoſe, to point out conciſely, the ſimpleſt and moſt practicable modes of obtaining, by experiment, the neceſſary information.

The only poiſons, however, that can be clearly and deciſively detected by chemical means, are thoſe of the mineral kingdom. Arſenic and corroſive ſublimate are moſt likely to be exhibited, with the view of producing death; and lead and copper may be introduced, undeſignedly, in ſeveral ways, into our food and drink. The continued operation of the two laſt may often, unſuſpected, produce effects leſs ſudden and violent, but not leſs baneful to health and life, than the more active poiſons; and their operation generally involves, in the pernicious conſequences, a greater number of ſufferers.

1. *Method of diſcovering Arſenic.*

When the cauſe of ſudden death is believed, from the ſymptoms preceding it, to be the adminiſtration of arſenic, the contents of the ſtomach muſt be attentively examined. To effect this, let a ligature be made at each orifice; the ſtomach removed entirely from the body; and its whole contents waſhed out into an earthen or glaſs veſſel. The arſenic, on account of its greater ſpecific gravity, will ſettle to the bottom, and may be obtained ſeparate, by waſhing off the other ſubſtances by repeated affuſions of cold water. Theſe waſhings ſhould not be thrown away, till the preſence of arſenic has been clearly aſcertained. It may be expected at the bottom of the veſſel in the form of a white powder, which muſt be carefully collected; dried on a filtre; and ſubmitted to experiment.

A. Boil a ſmall portion of the powder, with a few ounces of diſtilled water, in a clean Florence flaſk, and filtre the ſolution.

B. To this ſolution, add a portion of water ſaturated with ſulphurated hydrogen gas (ſee page 66). If arſenic be preſent, a golden yellow ſediment will fall down, which will appear ſooner, if a few drops of acetic acid be added.

C. A ſimilar effect is produced, by the addition of ſulphuret of ammonia.

D. To a little of the ſolution A, add a ſingle drop of a weak ſolution of carbonate of pot-aſh, and afterward a few drops of a ſolution of ſulphate of copper. The preſence of arſenic will be manifeſted by a yellowiſh green precipitate.

E. The ſediments, produced by any of the foregoing experiments, may be collected, dried, and laid on red hot charcoal. A ſmell of ſulphur will firſt ariſe, and will be followed by that of garlic.

F. But the moſt deciſive mode of determining the preſence of arſenic is by reducing it to a metallic ſtate, in which its characters are clear and unequivocal.

this purpoſe, let a portion of the white ſediment collected from the contents of the ſtomach, be mixed with three times its weight of black flux, ſee page 113, or, if this cannot be procured, with two parts of dry carbonate of pot-aſh (the ſalt of tartar of the ſhops) and one of powdered charcoal. Procure a tube eight or nine inches long and one fixth of an inch in diameter, of thin glaſs ſealed hermetically at one end. Coat the cloſed end with clay for about an inch, and let the coating dry. Then put into the tube the mixture of the powder and its flux, and if any ſhould adhere to the inner ſurface, let it be wiped off by a feather, ſo that the inner ſurface of the upper part of the tube may be quite clean. Stop the end of the tube looſely with a little paper, and heat the coated end only on a chafing diſh of red hot coals, taking care to avoid breathing the fumes. The arſenic, if preſent, will riſe to the upper part of the tube, on the inner ſurface of which it will form a thin brilliant coating. Break the tube and ſcrape off the reduced metal. Lay a little on a heated iron, when if it be arſenic, a denſe ſmoke will ariſe and a ſtrong ſmell of garlic will be perceived. The arſenic may be further identified, by putting a ſmall quantity between two poliſhed plates of copper: ſurrounding it by powdered charcoal, to prevent its eſcape; binding theſe tightly together by iron wire; and expoſing them to heat. If the included ſubſtance be arſenic, a white ſtain will be left on the copper.

G. It may be proper to obſerve that neither the ſtain on copper, nor the odour of garlic is produced by the white oxyd, when heated, without the addition of ſome inflammable ingredient. The abſenſe of arſenic muſt not, therefore, be inferred, if no ſmell is occaſioned by laying the white powder on a heated iron.

The late celebrated Dr. Black aſcertained, that all the neceſſary experiments, for the detection of arſenic, may be made on a ſingle grain of the white oxyd; this ſmall quantity having produced when heated in a tube with its proper flux, as much of the metal, as clearly eſtabliſhed its preſence.

If the quantity of arſenic, in the ſtomach, ſhould be ſo ſmall, which is not very probable, as to occaſion death, and yet to remain ſuſpended in the waſhings, the whole contents, and the water employed to waſh them, muſt be filtered, and the clear liquor aſſayed for arſenic by the teſts, B, C, D, and E.

2 *Diſcovery of Corroſive Sublimate.*

Corroſive ſublimate (the oxygenated muriate of mercury), next to arſenic, is the moſt virulent of the metallic poiſons. It may be collected by treating the contents of the ſtomach in the manner already deſcribed: but as it is more ſoluble than arſenic, viz. in about 19 times its weight of water; no more water muſt be employed than is barely ſufficient, and the waſhings muſt be carefully preſerved for examination.

If a powder ſhould be collected by this operation, which proves, on examination, not to be arſenic, it may be known to be corroſive ſublimate by the following characters.

A. Expoſe a ſmall quantity of it, without any admixture, to heat, in a coated glaſs tube, as directed in the treatment of arſenic. Corroſive ſublimate will be aſcertained by its riſing to the top of the tube, lining the inner ſurface, in the form of a ſhining white cruſt.

B. Diſſolve another portion in diſtilled water; and it may be proper to obſerve how much of the ſalt the water is capable of taking up.

C. To the watry ſolution, add a little lime water. A precipitate of an orange yellow colour will inſtantly appear.

D. To another portion of the ſolution, add a ſingle drop of a dilute ſolution of carbonate of pot-aſh (ſalt of tartar). A white precipitate will appear; but on a ſtill further addition of alkali, an orange coloured ſediment will be formed.

E. The carbonate of ſoda has ſimilar effects.

F. Sulphurated water throws down a dark coloured ſediment, which when dried and ſtrongly heated, is wholly volatilized, without any odour of garlic.

The only mineral poiſon, of great virulence, that has not been mentioned, and which from its being little known to act as ſuch, it is very improbable we ſhould meet with, is the carbonate of barytes. This, in the country where it is found, is employed as a poiſon for rats, and there can be no doubt would be equally deſtructive to human life. It may be diſcovered, by diſſolving it in muriatic acid, and by the inſolubility of the precipitate, which this ſolution yields, on adding ſulphuric acid (ſee page 97). Barytic ſalts, if theſe have been the means of poiſon, will be contained in the water employed to waſh the contents of the ſtomach, and will be detected on adding ſulphuric acid, by a copious precipitate.

3. *Method of detecting Copper or Lead.*

Copper and lead ſometimes gain admiſſion into articles of food, in conſequence of the employment of kitchen utenſils of theſe materials.

If copper be ſuſpected in any liquor, its preſence will be aſcertained by adding a ſolution of pure ammonia, which will ſtrike a beautiful blue colour. If the ſolution be very dilute, it may be concentrated by evaporation; and if the liquor contain a conſiderable exceſs of acid, like that uſed to preſerve pickles, as much of the alkali muſt be added, as is more than ſufficient to ſaturate the acid.

Lead is occaſionally found in ſufficient quantity to be injurious to health, in water that has been kept in leaden veſſels, and ſometimes even in pump water, in conſequence of the metal being uſed in the conſtruction of the pump. Acetite of lead has alſo been known to be fraudulently added to bad wines, with the view of con- their defects.

Lead may be diſcovered by adding to a portion of the ſuſpected water, about half its bulk of water impregnated with ſulphurated hydrogen gas. If lead be preſent, it will be manifeſted by a dark brown or blackiſh tinge. This teſt is ſo delicate, that water, condenſed by the leaden worm of a ſtill-tub is ſenſibly affected by it. It is, alſo, detected by a ſimilar effect enſuing on the addition of ſulphurets of ammonia or pot-aſh.

For diſcovering the preſence of lead in wines, a teſt invented by Dr Hahnemann, and known by the title of Hahnemann's wine teſt, may be employed. This teſt is prepared by putting together, into a ſmall vial, ſixteen grains of the ſulphuret of lime, prepared in the dry way (ſee page 87), and twenty grains of acidiulous tartrite of pot-aſh (cream of tartar). The vial is to be filled with water; well corked; and occaſionally ſhaken for the ſpace of ten minutes. When the powder has ſubſided; decant the clear liquor; and preſerve it in a well ſtopped bottle for uſe. The liquor, when freſh prepared, diſcovers lead by a dark coloured precipitate. A further proof of the preſence of lead in wines is the occurrence of a precipitate, on adding a ſolution of the ſulphate of ſoda.

SECTION II.

Rules for aſcertaining the Purity of Chemical Preparations employed for the Purpoſes of Medicine, and for other Uſes.

1. *Sulphuric Acid—Acidum Vitriolicum of the London Pharmacopœia.—Oil of Vitriol.*

The ſpecific gravity of ſulphuric acid ſhould be 1850. It ſhould remain perfectly tranſparent, when diluted with diſtilled water. If a ſediment ſhould occur, on dilution, it is a proof of the preſence of ſulphate of lead or lime.

Iron will be detected in ſulphuric acid, by ſaturating a diluted portion of it with pure carbonate of ſoda, and adding pruſſiate of pot-aſh, which will manifeſt the preſence of iron by a pruſſian blue precipitate; or it will be diſcovered by a purpliſh or blackiſh tinge, on the addition of tincture of galls, to a ſimilarly ſaturated portion. Copper may be diſcovered, by pouring, into a ſimilar ſaturated ſolution, pure ſolution of ammonia; and lead may be detected by the ſulphuret of ammonia. The latter metal, however, is generally precipitated, on dilution, in combination with ſulphuric acid.

Sulphate of pot-aſh or of ſoda may be found, by ſaturating the diluted acid with ammonia, evaporating to dryneſs, and applying a pretty ſtrong heat. The ſulphate of ammonia will eſcape; and that of pot-aſh or of ſoda will remain, and may be diſtinguiſhed by its ſolubility and other characters. (See page 64.)

2. *Nitric and Nitrous Acids—Acidum Nitroſum, Pharm. Lond. Aqua-fortis.*

The nitric acid ſhould be perfectly colourleſs and as limpid as water. It ſhould be preſerved in a dark place; to prevent its converſion into the nitrous kind.

Theſe acids are moſt likely to be adulterated with ſulphuric and muriatic acids. The ſulphuric acid may be diſcovered by adding to a portion of the acid, largely diluted, nitrated or muriated barytes, which occaſion, with ſulphuric acid, a white and inſoluble precipitate. The muriatic acid may be aſcertained by nitrate of ſilver, which affords a ſediment, at firſt white, but which becomes coloured, by expoſure to the direct light of the ſun. Both theſe acids, however, may be preſent at once; and in this caſe, it will be neceſſary to add a ſolution of nitrate of barytes, as long as any precipitate falls, which will ſeparate the ſulphuric acid. Let the ſediment ſubſide; decant the clear liquor; and add the nitrate of ſilver. If a precipitate appear, muriatic acid may be inferred to be preſent alſo. Muriatic acid may alſo be detected by adding a ſolution of ſulphate of ſilver.

Theſe acids ſhould have the ſpecific gravity of 1550.

3. *Muriatic Acid—Acidum Muriaticum, P. L. Spirit of Salt.*

This acid generally contains iron, which may be known by its yellow colour, the pure acid being perfectly colourleſs. It may alſo be detected by the ſame mode, as was recommended in examining ſulphuric acid.

Sulphuric acid is diſcoverable by a precipitation, on adding to a portion of the acid, diluted with five or ſix parts of pure water, a ſolution of the muriate of barytes.

The ſpecific gravity of this acid ſhould be 1170.

4. *Acetic Acid—Acidum Acetoſum, P. L. Radical or concentrated Vinegar.*

This acid is often contaminated by ſulphureous and ſulphuric acid. The firſt may be known by drawing a little of the vapour into the lungs, when if the acid be pure, no unpleaſant ſenſation will be felt; but if ſulphureous acid be contained in the acetic, it will not fail to be diſcovered in this mode. The ſulphuric acid is detected by muriated barytes: Copper by ſuper-ſaturation with pure ammonia: and lead by ſulphuret of ammonia.

The ſpecific gravity of this acid ſhould be 1050 at leaſt.

5. *Acetous Acid.—Acetum Diſtillatum. P. L. Diſtilled Vinegar.*

If vinegar be diſtilled in copper veſſels, it can hardly fail being contaminated by that metal; and if a leaden

worm be uſed, for its condenſation, ſome portion of
will certainly be diſſolved. The former metal will
pear, on adding an exceſs of ſolution of pure am
nia; and lead will be detected by the ſulphurated
monia, or by water ſaturated with ſulphurated hydrog

It is not unuſual, in order to increaſe the acid taſt
vinegar, to add ſulphuric acid. This acid may be
mediately diſcovered, by ſolutions of barytes, whi
when vinegar has been thus adulterated, throw dow
white precipitate.

6. *Boracic Acid—Sedative Salt of Homberg.*

Genuine boracic acid ſhould totally diſſolve in
times its weight of boiling alcohol; and the ſoluti
when ſet on fire ſhould emit a green flame. The
boracic acid forms ſmall hexangular ſcaly cryſtals, o
ſhining ſilvery white colour. Its ſpecific gravity is 14

7. *Tartarous Acid.*

This acid often contains ſulphuric acid, to diſco
which, let a portion be diſſolved in water, and a ſo
tion of acetite of lead be added. A precipitate will
pear, which if the acid be pure, is entirely re-diſſol
by a few drops of pure nitric acid, or by a little p
acetic acid. If any portion remain undiſſolved,
phuric acid is the cauſe. Muriate of barytes, alſo, wh
the acid is adulterated with ſulphuric acid, but not oth
wiſe, gives a precipitate inſoluble by an exceſs of m
riatic acid.

8. *Acid of Amber.*

Acid of amber is adulterated, ſometimes with
phuric acid and its combinations; ſometimes with t
tareous acid; and at others with muriate of ammoni

Sulphuric acid is detected by ſolutions of baryte
tartareous acid by carbonate of pot-aſh, which forms
difficultly ſoluble tartrite; and muriate of ammonia

nitrate of ſilver, which diſcovers the acid, and by a ſolution of pure pot-aſh, which excites a ſtrong ſmell of ammonia.

Pure acid of amber is a cryſtalline white ſalt; of an acid taſte; ſoluble in twenty-four parts of cold and eight of hot water; and is volatilized when laid on red hot iron, without leaving any aſhes or other reſidue.

9. *Acid of Benzoin—Flores Benzoes, P. L.*

This acid is not very liable to adulteration. The beſt has a brilliant white colour, and a peculiarly grateful ſmell. It is ſoluble in a large quantity of boiling water or alcohol; and leaves no reſidue, when placed on a heated iron.

10. *Carbonate of Pot-aſh.—Kali Preparatum, P. L.*

The ſalt of tartar of the ſhops generally contains ſulphate and muriate of pot-aſh, and ſiliceous and calcareous earths. It ſhould diſſolve entirely, if pure, in twice its weight of cold water; and any thing, that remains undiſſolved, may be regarded as an impurity. Sometimes one fourth of foreign admixtures may thus be detected, the greater part of which is ſulphate of pot-aſh. To aſcertain the nature of the adulteration, diſſolve a portion in pure and diluted nitric acid. The ſiliceous earth only will remain undiſſolved. Add, to one portion of the ſolution, nitrate of barytes. This will detect ſulphate of pot-aſh by a copious precipitate. To another portion add nitrate of ſilver, which will diſcover muriatic ſalts; and to a third oxalate or fluate of ammonia, which will detect calcareous earth.

The ſolution of carbonate of pot-aſh (Aqua Kali, P. L.) may be examined in a ſimilar manner.

11. *Solution of pure Pot-aſh—Aqua Kali Puri, P. L.*

This may be aſſayed for ſulphuric and muriatic ſalts by ſaturation with nitric acid, and by the teſts recommended in ſpeaking of carbonate of pot-aſh. A perfectly pure ſolution of pot-aſh ſhould remain tranſparent, on the addition of barytic water. If a precipitate ſhould enſue, which diſſolves, with efferveſcence, in dilute muriatic acid, it is owing to the preſence of carbonic acid; if the precipitate is not ſoluble, it indicates ſulphuric acid. A redundancy of carbonic acid is, alſo, ſhewn by an efferveſcence on adding diluted ſulphuric acid; and an exceſs of lime, by a white precipitate, on blowing air, from the lungs, through the ſolution, by means of a tobacco pipe, or a glaſs tube.

This ſolution ſhould be of ſuch a ſtrength, as that an exact wine pint may weigh 18 ounces troy.

12. *Carbonate of Soda—Natron Preparatum, P. L.*

Carbonate of ſoda is ſcarcely ever found free from muriate and ſulphate of ſoda. Theſe may be diſcovered by adding, to a little of the carbonate ſaturated with pure nitric acid, firſt nitrate of barytes, to detect ſulphuric acid; and afterward nitrate of ſilver, to aſcertain the preſence of muriatic acid. Carbonate of pot-aſh will be ſhown by a precipitate enſuing, on the addition of tartarous acid to a ſtrong ſolution of the alkali; for this acid forms a difficultly ſoluble ſalt with pot-aſh, but not with ſoda.

13. *Solution of Carbonate of Ammonia—Aqua Ammoniæ. P. L.*

This ſhould have the ſpecific gravity of 1150; ſhould efferveſce on the addition of acids; and ſhould afford a ſtrong coagulum, on adding alcohol.

14. *Carbonate of Ammonia—Ammonia Preparata. P. L.*

The ſalt ſhould be entirely volatilized by heat. If any thing remain, when it is laid on a heated iron, carbonate of pot-aſh or of lime may be ſuſpected; and theſe impurities are moſt likely to be preſent, if the carbonate of ammonia be purchaſed in the form of a powder. It ſhould therefore always be bought in ſolid lumps. Sulphuric and muriatic ſalts, lime, and iron, may be diſcovered by adding to the alkali, ſaturated with nitric acid, the appropriate teſts, already often mentioned.

15. *Solution of Pure Ammonia in Water—Aqua Ammoniæ Puræ, P. L.—Strong Spirit of Sal Ammoniac.*

The volatile alkali, in its pureſt ſtate, exiſts as a gas, condenſible by water; and its ſolution in water is the only form under which it is applicable to uſeful purpoſes. This ſolution ſhould contain nothing beſides the volatile alkali; the alkali ſhould be perfectly free from carbonic acid; and ſhould be combined with water, in the greateſt poſſible proportion. The preſence of other ſalts may be diſcovered, by ſaturating a portion of the ſolution with pure nitric acid, and adding the teſts for ſulphuric and muriatic acids. Carbonic acid is ſhown by a precipitation, on mixing the ſolution with one of muriate of lime; for this earthy ſalt is not precipitated by pure ammonia. The only mode of determining the ſtrength of the ſolution, is by taking its ſpecific gravity, which at 60°, of Faht. ſhould be as 905, or thereabouts, to 1000.

16. *Spirit of Hartſhorn.—Liquor Volatilis Cornu Cervi, P. L.*

This may be counterfeited by mixing the aqua ammoniæ puræ with the diſtilled ſpirit of hartſhorn, in order to increaſe the pungency of its ſmell, and to enable it to bear an addition of water. The fraud is detected by adding alcohol to the ſophiſticated ſpirit; for if no conſiderable coagulation enſues, the adulteration is proved. It may alſo be diſcovered by the uſual efferveſcence not enſuing with acids. The ſolution ſhould have the pe cific gravity of 1500.

17. *Sulphate of Soda—Natron Vitriolatum, P. L. Glauber's Salt.*

This ſalt ought not to contain an exceſs of either aci or alkali, both of which may be detected by the vegetable infuſions, page 132, nor ſhould it be mixed with earthy or metallic ſalts; the former of which are detected by carbonate, and the latter by pruſſiate of pot-aſh. Muriate of ſoda is diſcovered, by adding nitrate of barytes, till the precipitate ceaſes; and afterwards nitrate of ſilver, or more ſimply by a ſolution of ſulphate of ſilver. Sulphate of pot-aſh is diſcovered by its more ſparing ſolubility. The ſulphate of ſoda, however, being itſelf one of the cheapeſt ſalts, there is little riſk of its being intentionally ſophiſticated.

18. *Sulphate of Pot-aſh—Kali Vitriolatum, P. L. Vitriolated Tartar.*

The purity of this ſalt may be aſcertained by the ſame means, as that of the former one. The little value of this ſalt renders it pretty ſecure from wilful adulteration.

19. *Nitrate of Pot-aſh—Nitrum Purificatum, P. L. Nitre or Salt Petre.*

Nitrate of pot-aſh is, with great difficulty, freed entirely from muriate of ſoda; and a ſmall portion of the latter, except for nice chemical purpoſes, is an admixture of little importance. To diſcover muriate of ſoda, a ſolution of nitrate of ſilver muſt be added as long as any ſediment is produced. The precipitate, waſhed and dried, muſt be weighed. Every hundred grains will denote 42½ of muriate of ſoda.

Sulphate of pot-aſh or ſoda may be diſcovered by nitrate or muriate of barytes.

20. *Muriate of Soda—Common Salt.*

Common ſalt is ſcarcely ever found free from ſalts with earthy baſes, chiefly muriates of magneſia and lime, which are contained in the brine, and adhere to the cryſtals. The earths may be precipitated by carbonate of ſoda; and the precipitated lime and magneſia may be ſeparated from each other by the rules given, page 156.

21. *Muriate of Ammonia—Ammonia Muriata, P. L. Sal Ammoniac.*

This ſalt ought to be entirely volatilized by a low heat, when laid on a heated iron. It ſometimes contains ſulphate of ammonia, however, which, being alſo volatile, cannot be thus detected. To aſcertain the preſence of the latter ſalt, add the muriate or nitrate of barytes, which will indicate the ſulphate, by a copious and inſoluble precipitate.

22. *Acetite of Pot-aſh—Kali Acetatum, P. L.*

Genuine acetite of pot-aſh is perfectly ſoluble in four times its weight of alcohol, and is thus ſeparable from other ſalts, that are inſoluble in alcohol. The tartrite of pot aſh (ſoluble tartar) is the adulteration moſt likely to be employed. This may be diſcovered by adding a ſolution of tartarous acid, which, if the ſuſpected ſalt be preſent will occaſion a copious precipitate. The tartrite is alſo detected by its forming a precipitate, with acetite of lead or muriate of barytes, ſoluble in acetic or muriatic acid; and ſulphates, by a precipitate with the ſame agents, inſoluble in acids.

23. *Neutral Tartrite of Pot-aſh.—Kali Tartarizatum, P. L.—Soluble Tartar.*

This ſalt ſhould afford a very copious precipitate on adding tartarous acid. The only ſalt likely to be mixed with it, is ſulphate of ſoda, which may be detected by a precipitate with muriated barytes, inſoluble in diluted muriatic acid.

24. *Acidulous Tartrite of Pot-aſh—Tartarum Purificatum.—Cream of Tartar.*

The only ſubſtance, with which this ſalt is likely to be adulterated, is ſulphate of pot-aſh. To determine whether this be preſent, pour on about half an ounce of the powdered cryſtals, two or three ounce meaſures of diſtilled water; ſhake the mixture frequently; and let it ſtand one or two hours. The ſulphate of pot-aſh, being more ſoluble than the tartrite will be taken up; and may be known by the bitter taſte of the ſolution, and by a precipitate, on adding muriate of barytes, which will be inſoluble in muriatic acid.

25. *Compound Tartrite of Soda and Pot-aſh—Natron Tartarizatum. P. L.—Rochelle or Seignetto's Salt.*

Sulphate of ſoda, the only ſalt, with which this may be expected to be adulterated, is diſcovered by adding to a ſolution of Rochelle ſalt, the acetite of lead or muriate of barytes.—The former if the ſulphate be preſent affords a precipitate, inſoluble in acetous acid; and the later one inſoluble in muriatic acid.

26. *Sulphate of Magneſia.—Magneſia Vitriolata, P. L.—Epſom Salt.*

This ſalt is very likely to be adulterated with ſulphate of ſoda, or Glauber's ſalt, which may be made to reſemble the magneſian ſalt in appearance, by ſtirring it briſkly at the moment it is about to cryſtalize. The fraud may be diſcovered, very readily, if the ſalt conſiſt entirely of the ſulphate of ſoda, becauſe no precipitation will enſue on adding carbonate of pot-aſh. If only a part of the ſalt be ſulphate of ſoda, detection is eaſy; but may ſtill be accompliſhed. For ſince

10 parts of pure ſulphate of magneſia give between 30 and 40 of the dry carbonate, when completely decompoſed by carbonate of pot-aſh; if the ſalt under examination affords a conſiderable leſs proportion, its ſophiſtication may be fairly inferred: Or, to diſcover the ſulphate of ſoda, precipitate all the magneſia by pure ammonia, with the aid of heat. Decant the clear liquor from the precipitate; filtre it; and after evaporation to dryneſs, apply ſuch a heat as will volatilize the ſulphate of ammonia, when that of ſoda will remain fixed.

Muriate of magneſia or of lime may be detected, by the ſalt becoming moiſt when expoſed to the air; and by a precipitation with nitrated ſilver, after nitrate of barytes has ſeparated all the ſulphuric acid and magneſia. Lime is diſcoverable by oxalic acid.

27. *Sulphate of Alumine.—Allum.*

Perfectly pure allum ſhould contain neither iron nor copper. The former is manifeſted by adding, to a ſolution of allum, pruſſiate of pot-aſh; and the latter by an exceſs of pure ammonia.

28. *Borate of Soda.—Borax.*

Borate of ſoda, if adulterated at all, will probably be ſo, with allum or fuſed muriate of ſoda. To diſcover theſe, borax muſt be diſſolved in water, and its exceſs of alkali be ſaturated with nitric acid. Nitrate of barytes, added to the ſaturated ſolution, will detect the ſulphuric ſalt, and nitrate of ſilver the muriate of ſoda.

29. *Sulphate of Iron—Ferrum Vitriolatum. P. L. Green Vitriol.*

If this ſalt ſhould contain copper, which is the only admixture likely to be found in it, pure ammonia, added till a precipitation ceaſes, will afford a blue liquor. Any copper that may chance to be preſent, may be ſe-

34. *Red Oxyd of Mercury—Hydrargyrus Calcinatus, P. L.*

This ſubſtance is rarely found adulterated, as it would be difficult to find a ſubſtance well ſuited to this purpoſe. If well prepared, it may be totally volatillized by heat.

35. *Red Oxyd of Mercury by Nitric Acid—Hydrargyrus Nitratus Ruber, P. L.—Red Precipitate.*

This is very liable to adulteration with minium or red lead. The fraud may be diſcovered by digeſting it in acetic acid, and adding to the ſolution ſulphurated water, or ſulphuret of ammonia, which produce, with the compounds of lead a dirty dark coloured precipitate. It ſhould, alſo, be totally volatilized by heat.

36. *White Oxyd of Mercury.—Calx Hydrargyri Alba, P. L.—White Precipitate.*

White lead is the moſt probable adulteration of this ſubſtance, and chalk may, alſo, be occaſionally mixed with it. The oxyd of lead may be diſcovered as in the laſt article; and chalk, by adding to the dilute ſolution, a little oxalic acid.

37. *Red Sulphurated Oxyd of Mercury.—Hydrargyrus Sulphuratus Ruber, P. L.—Factitious Cinnabar.*

This ſubſtance is frequently adulteratd with red lead, which may be detected by the foregoing rules.—Chalk and dragon's blood are alſo ſometimes mixed with it. The chalk is diſcovered by an effervеſcence on adding acetic acid, and by pouring oxalic acid into the acetous ſolution. Dragon's blood will be left unvolatilized, when the ſulphuret is expoſed to heat; and may be detected by its giving a colour to alcohol, when the cinnabar is digeſted with it.

38. *Black Sulphurated Oxyd of Mercury—Hydrargyrus cum Sulphure, P. L—Ethiops Mineral.*

The mercury and ſulphur, in this preparation, ſhould be ſo intimately combined, that no globules of the metals can be diſcovered by a magnifier; and that, when rubbed on gold, no white ſtain may be communicated. The admixture of ivory black may be detected, by its not being wholly volatilized by heat; or by boiling with alkali to extract the ſulphur, and afterwards expoſing the reſiduum to heat, which ought entirely to evaporate.

39. *Yellow Oxyd of Mercury.—Hydrargyrus Vitriolatus, P. L.—Turbith Mineral.*

This preparation ſhould be wholly evaporable; and when digeſted with diſtilled water, the water ought not to take up any ſulphuric acid, which will be diſcovered by muriate of barytes.

40. *Fuſed Nitrate of Silver—Argentum Nitratum, P. L.—Lunar Cauſtic.*

The moſt probable admixture, with this ſubſtance, is nitrate of copper, derived from the employment of an impure ſilver. In moderate proportion, this is of little importance. It may be aſcertained by ſolution in water, and adding an exceſs of pure ammonia, which will detect copper by a deep blue colour.

41. *White Oxyd of Zinc—Zincum Calcinatum, P. L.—Flowers of Zinc.*

Oxyd of zinc may be adulterated with chalk, which is diſcoverable by an effervescence with acetous acid, and by the precipitation of this ſolution with oxalic acid. Lead is detected by adding, to the acetous ſolution, ſulphurated water, or ſulphuret of ammonia. Arſenic.

to which the activity of this medicine has been ſometimes aſcribed, is detected, alſo, by ſulphurated water, added to the acetous ſolution, but in this caſe the precipitate has a yellow colour; and when laid on red hot charcoal, gives firſt a ſmell of a ſulphur, and afterwards of arſenic.

42. *White Oxyd of Lead.—Ceruſſa, P. L. White Lead.*

This is frequently ſophiſticated with chalk, the preſence of which may be detected by cold acetous acid, and by adding to this ſolution oxalic acid. Carbonate of barytes is detected by ſulphate of ſoda added to the ſame ſolution, very largely diluted with diſtilled water; and ſulphate of barytes or ſulphate of lead, by the inſolubility of the ceruſſe in diſtilled vinegar.

43. *Acetite of Lead.—Ceruſſa Acetata, P. L.—Sugar of Lead.*

If the acetite of lead ſhould be adulterated with acetite of lime or of barytes, the former may be detected by adding to a dilute ſolution, the oxalic acid; and the latter by ſulphuric acid, or ſolution of ſulphate of ſoda, added to a ſolution very largely diluted with water. Acetite of lead ought to diſſolve entirely in water; and any thing that reſiſts ſolution may be regarded as an impurity.

44. *Green Oxyd of Copper—Verdegris.*

This oxyd is ſcarcely ever found pure, being mixed with pieces of copper, grape ſtalks, and other impurities. The amount of this admixture of inſoluble ſubſtances may be aſcertained, by boiling a portion of verdegris, with 12 or 14 times its weight of diſtilled vinegar; allowing the undiſſolved part to ſettle; and aſcertaining its weight. Sulphate of copper may be detected, by boiling the verdegris with water, and evaporating the ſolution. Cryſtals of acetite of copper will firſt ſeparate; and when the ſolution has been further concentrated, the ſulphate of copper will cryſtallize. Or it may be diſcovered, by adding, to the watery ſolution, muriate of barytes, which will throw down a very abundant precipitate. Tartrite of copper, another adulteration ſometimes met with, is diſcovered by diſſolving a little of the verdegris in acetous acid, and adding acetite or muriate of barytes, which will afford with the tartarous acid a precipitate, ſoluble in muriatic acid.

45. *Cryſtallized Acetite of Copper.—Diſtilled or Cryſtalized Verdegris.*

This is prepared by diſſolving the common verdegris in diſtilled vinegar, and cryſtallizing the ſolution. Theſe cryſtals ſhould diſſolve entirely in ſix times their weight of boiling water; and the ſolution ſhould give no precipitation with ſolutions of barytes; for if theſe ſolutions throw down a precipitate, ſulphate of copper is indicated. This impurity, which I have frequently met with, may be diſcovered, by evaporating the ſolution very low and ſeparating the cryſtals of acetite of copper. Further evaporation and cooling will cryſtallize the ſulphate, if any be preſent.

46. *Carbonate of Magneſia—Magneſia Alba, P. L.*

Carbonate of magneſia is moſt liable to adulteration with chalk; and as lime forms with ſulphuric acid a very inſoluble ſalt, and magneſia one very readily diſſolved, this acid may be employed in detecting the fraud. To a ſuſpected portion of magneſia, add a little ſulphuric acid, diluted with 8 or 10 times its weight of water. If the magneſia ſhould entirely be taken up, and the ſolution ſhould remain tranſparent, it may be pronounced pure; but not otherwiſe. Another mode of diſcovering the deception is as follows. Saturate a portion of the ſuſpected magneſia with muriatic acid; and add a ſolution of carbonate of ammonia. If any lime be preſent, it will form an inſoluble precipitate, but the magneſia will remain in ſolution.

47. *Pure Magneſia.—Magneſia Uſta, P. L.—Calcined Magneſia.*

Calcined magneſia may be aſſayed by the ſame teſts as the carbonate. It ought not to efferveſce at all with dilute ſulphuric acid; and if the earth and acid be put together into one ſcale of a balance, no diminution of weight ſhould enſue on mixing them together. It ſhould be perfectly free from taſte, and when digeſted with diſtilled water, the filtered liquor ſhould manifeſt no property of lime water. Calcined magneſia, however, is very ſeldom ſo pure as to be totally diſſolved by diluted ſulphuric acid; for a ſmall inſoluble reſidue generally remains, conſiſting chiefly of ſiliceous earth, derived from the alkali. The ſolution in ſulphuric acid, when largely diluted, ought not to afford any precipitation with oxalate of ammonia.

48. *Spirit of Wine; Alcohol; and Æthers.*

The only deciſive mode of aſcertaining the purity of ſpirit of wine and of ethers, is by determining their ſpecific gravity. Highly rectified alcohol ſhould have the ſpecific gravity of 829 to 1000. Common ſpirit of wine 837. Sulphuric ether 739. The ſpiritus ætheris vitriolicus, P. L, or ſweet ſpirit of vitriol, about 753 —and nitric ether, the ſpiritus etheris nitroſus, or ſweet ſpirit of nitre, 908. The ethers ought not to redden the colour of litmus; nor ought thoſe, formed from ſulphuric acid, to give any precipitation with ſolutions of barytes.

49. *Eſſential or Volatile Oils.*

As eſſential oils conſtitute only a very ſmall proportion of the vegetables, from which they are obtained, and bear generally a very high price, there is a conſiderable temptation to adulterare them. They are found ſophiſticated, either with cheaper volatile oils, with fixed oils, or with ſpirit of wine. The fixed oils are diſcovered, by diſtillation with a very gentle heat, which elevates the eſſential oils, and leaves the fixed ones. Theſe laſt may, alſo, be detected by moiſtening a little writing paper with the ſuſpected oil, and holding it before the fire. If the oil be entirely eſſential, no ſtain will remain on the paper. Alcohol, alſo, detects the fixed oils, becauſe it only diſſolves the eſſential ones; and the mixture becomes milky. The preſence of cheaper eſſential oils is diſcovered by the ſmell.' Alcohol, a cheaper liquid than ſome of the moſt coſtly oils, is diſcovered by adding water, which, if alcohol be preſent, occaſions a milkineſs.

SECTION III.

Uſe of Chemical Re-agents to certain Artiſts and Manufacturers.

To point out all the beneficial applications of chemical ſubſtances to the purpoſes of the arts, would require a diſtinct and very extenſive treatiſe. In this place, I have no further view than to deſcribe the mode of detecting adulterations in certain articles of commerce, the ſtrength and purity of which are eſſential to the ſucceſs of chemical proceſſes.

1. *Mode of detecting the Adulteration of Pot-aſhes, Pearl-aſhes, and Barilla.*

Few objects of commerce are ſophiſticated to a greater extent than the alkalis, to the great loſs and injury of the bleacher, the dyer, the glaſs-maker, the ſoap-boiler, and of all other artiſts who are in the habit of employing theſe ſubſtances. In the firſt part of this work (ſee page 55) I have already given rules for diſcovering ſuch adulterations; and to what has been ſaid, I apprehend it is only neceſſary to add the directions of Mr. Kirwan, intended to effect the ſame end, but differing in the mode. They are tranſcribed from his paper, entitled "Experiments on the Alkaline Subſtances uſed in Bleaching;"—ſee Tranſactions of the Iriſh Academy for 1789.

"To diſcover whether any quantity of fixed alkali worth attention exiſts in any ſaline compound, diſſolve one ounce of it in boiling water, and into this ſolution let fall a drop of a ſolution of ſublimate corroſive; this will be converted into a brick colour, if an alkali be preſent, or into a brick colour mixed with yellow, if the ſubſtance tried contains lime.

"But the ſubſtances uſed by bleachers being always impregnated with an alkali, the above trial is in general ſuperfluous, except for the purpoſe of detecting lime. The quantity of alkali is therefore what they ſhould chiefly be ſolicitous to determine, and for this purpoſe:

"1ſt. Procure a quantity of allum, ſuppoſe one pound, reduce it to powder, waſh it with cold water, and then put it into a tea-pot, pouring on it three or four times its weight of boiling water.

"2dly. Weigh an ounce of the aſh or alkaline ſubſtance to be tried, powder it, and put it into a Florence flaſk with one pound of pure water (common water boiled for a quarter of an hour, and afterwards filtered through paper, will anſwer) if the ſubſtance to be examined be of the nature of barilla, or pot-aſh; or half a pound of water if it contain but little earthy matter, as pearl-aſh; let them boil for a quarter of an hour: when cool let the ſolution be filtered into another Florence flaſk.

"3dly. This being done, gradually pour the ſolution of allum hot into the alkaline ſolution alſo heated;

a precipitation will immediately appear; ſhake them well together, and let the efferveſcence, if any, ceaſe before more of the aluminous ſolution be added; continue the addition of the allum until the mixed liquor, when clear, turns ſyrup of violets, or paper tinged blue by radiſhes, or by litmus, red; then pour the liquor and precipitate on a paper filter placed in a glaſs funnel. The precipitated earth will remain on the filter; pour on this a pound or more of hot water gradually, until it paſſes taſteleſs; take up the filter, and let the earth dry on it until they ſeparate eaſily. Then put the earth into a cup of Staffordſhire ware, place it on hot ſand, and dry the earth until it ceaſes to ſtick to glaſs or iron; then pound it, and reduce it to powder in the cup with a glaſs peſtle, and keep it a quarter of an hour in a heat of from 470° to 500°.

" 4thly. The earth being thus dried, throw it into a Florence flaſk, and weigh it; then put about one ounce of ſpirit of ſalt into another flaſk, and place this in the ſame ſcale as the earth, and counter-balance both in the oppoſite ſcale: this being done, pour the ſpirit of ſalt gradually into the flaſk that contains the earth; and when all efferveſcence is over (if there be any) blow into the flaſk, and obſerve what weight muſt be added to the ſcale containing the flaſks, to reſtore the equilibrium; ſubtract this weight from that of the earth, the remainder is a weight exactly *proportioned* to the weight of mere alkali of that particular ſpecies which is contained in one ounce of the ſubſtance examined; all beſide is ſuperfluous matter.

" I have ſaid that alkalies of the *ſame ſpecies* may thus be directly compared, becauſe alkalies of *different* ſpecies cannot but require the intervention of another proportion; and the reaſon is, becauſe *equal* quantities of alkalies of different ſpecies precipitate *unequal* quantities of earth of allum. Thus 100 parts by weight of mere *vegetable* alkali, precipitate 78 of earth of allum; but 100 parts of *mineral* alkali precipitate 170,8 parts of that earth. Therefore the precipitation of 78 parts of earth of allum by vegetable alkali, denotes as much of this as the precipitation of 170,8 of that earth by the mineral alkali denotes of the mineral alkali. Hence the quantities of alkali in all the different ſpecies of pot-aſhes, pearl-aſhes, weed, or wood-aſhes, may be immediately compared with the above teſt, as they all contain the vegetable alkali; and the different kinds of kelp or kelps manufactured in different places, and the different ſorts of barilla, may thus be compared, becauſe they all contain the mineral alkali. But kelps and pot-aſhes, as they contain different ſorts of alkali, can only be compared together by means of the proportion above indicated."

2. *Mode of detecting the Adulteration of Manganeſe.*

In the Section on drugs, inſtructions may be found for diſcovering impurities in ſeveral chemical preparations, employed by the artiſt, as ceruſſe or white lead; red lead; verdegris, &c. No rules, however, have been given for examining manganeſe, which is a ſubſtance that varies much in quality, and is often ſophiſticated; as the bleachers experience, to their no ſmall diſappointment and loſs.

The principal defect of manganeſe ariſes from the admixture of chalk, which is not always an intentional adulteration; but is ſometimes found united with it, as it occurs in the earth. When to this impure manganeſe, mixed with muriate of ſoda (ſee page 78), the ſulphuric acid is added, the materials effervеſce and ſwell conſiderably; and a large proportion paſſes into the receiver, in conſequence of which the bleaching liquor is totally ſpoiled. This misfortune has, to my knowledge, frequently happened; and can only be prevented by ſo ſlow and cautious an addition of the acid, as is nearly inconſiſtent with the buſineſs of an extenſive bleaching work. The preſence of carbonate of lime may be diſcovered in manganeſe, by pouring, on a portion of this ſubſtance, nitric acid diluted with 8 or ten parts of water. If the manganeſe be good, no effervescence will enſue; nor will the acid diſſolve any thing; but if carbonate of lime be preſent, it will be taken up by the acid. To the ſolution, add a ſufficient quantity of carbonate of pot-aſh to precipitate the lime; waſh the ſediment with water; and dry it. Its weight will ſhow, how much chalk the manganeſe under examination contained.

Another adulteration of manganeſe, that may, perhaps, be ſometimes practiſed, is the addition of ſome ores of iron. This impurity is leſs eaſily diſcovered. But if the iron be in ſuch a ſtate of oxydation as to be ſoluble in muriatic acid, the following proceſs may diſcover it. Diſſolve a portion, with the aſſiſtance of heat, in concentrated muriatic acid; dilute the ſolution largely with diſtilled water; and add a ſolution of cryſtallized carbonate of pot-aſh. The manganeſe will remain ſuſpended by the exceſs of carbonic acid, on mixing the two ſolutions; but the iron will be precipitated in the ſtate of a coloured oxyd.

SECTION IV.

Application of Chemical Teſts to the Uſes of the Farmer and Country Gentleman.

The benefits that might be derived, from the union of chemical ſkill with extenſive obſervation of agricultural facts, are, perhaps, incalculable. At preſent, however, the ſtate of knowledge, among farmers, is not ſuch, as to enable them to reap much advantage from chemical experiments; and the chemiſt has, himſelf, ſcarcely ever opportunities of applying his knowledge to practical purpoſes, in this way. It may, perhaps, however, be of uſe to offer a few brief directions for the analyſis of marls, lime-ſtones, &c. and, on this occaſion, I ſhall owe much of my information, as in various other parts of this work, to the writings of Mr. Kirwan, whoſe pamphlet on philoſophical agriculture, I ſtrongly recommend to general peruſal.*

1. *Lime.*

It is impoſſible to lay down any general rules reſpecting the fitneſs of lime for the purpoſes of agriculture, becauſe much muſt depend on the peculiarities of ſoil, expoſure, and other circumſtances. Hence a ſpecies of lime may be extremely well adapted for one kind of land, and not for another. All that can be accompliſhed by chemical means, is to aſcertain the degree of purity of the lime, and to infer, from this, to what kind of ſoil it is beſt adapted. Thus a lime, which contains much argillaceous earth, is better adapted, than a purer one, to dry and gravelly ſoils; and ſtiff clayey lands require a lime as free as poſſible from the argillaceous ingredient.

To determine the purity of lime, let a given weight be diſſolved in diluted muriatic acid. Let a little exceſs of acid be added, that no portion may remain undiſſolved, owing to the deficiency of the ſolvent. Dilute with diſtilled water, let the inſoluble part, if any, ſubſide; and the clear liquor be decanted. Waſh the ſediment with further portions of water; and pour it upon a filter previouſly weighed. Dry the filter, and aſcertain its increaſe of weight, which will indicate how much inſoluble matter, the quantity of lime, ſubmitted to experiment, contained. It is eaſy to judge, by the external qualities of the inſoluble portion, whether argillaceous earth abounds in its compoſition.

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* It is entitled "The Manures moſt advantageouſly applicable to the various ſorts of ſoils; and the cauſes of their beneficial effects in each particular inſtance; by R. Kirwan, Eſq.—London 1796."

There is one earth, however, lately found in ſeveral lime-ſtones, which is highly injurious to the vegetation of plants, and is not diſcoverable by the foregoing proceſs, being, equally with lime, ſoluble in muriatic acid. This earth, is magneſia, which, by direct experiments, has been aſcertained to be extremely noxious to plants. Mr. Tennant, the gentleman to whom we owe this fact, was informed, that in the neighbourhood of Doncaſter, two kinds of lime were employed, one of which, it was neceſſary to uſe ſparingly, and to ſpread very evenly; for it was ſaid that a large proportion, inſtead of increaſing, diminiſhed the fertility of the ſoil, and that whenever a heap of it was left in one ſpot, all fertility was prevented for many years. Fifty or ſixty buſhels, on an acre, were conſidered to be as much as could be uſed with advantage. The other ſort of lime, which was obtained from a village near Ferrybridge, though conſiderably dearer, from the diſtant carriage, was more frequently employed on account of its ſuperior utility. A large quantity was never found to be injurious; and the ſpots, which were covered with it, inſtead of being rendered barren, became remarkably fertile. On examining the compoſition of theſe two ſpecies of lime, the fertilizing one proved to conſiſt entirely of calcareous earth; and the noxious one of three parts lime and two magneſia.

The preſence of magneſia in lime proved, on further inveſtigation, to be a very common occurrence. The magneſian lime-ſtone appears to extend for 30 or 40 miles, from a little ſouth-weſt of Workſop, in Nottinghamſhire, to near Ferrybridge in Yorkſhire; and it has alſo been found at Breedon and Matlock in Derbyſhire.

The magneſian lime-ſtone, according to Mr. Tennant, may eaſily be diſtinguiſhed, from that which is purely calcareous, by the ſlowneſs of its ſolution in acids, which is ſo conſiderable, that even the ſofteſt kind of the former is much longer in diſſolving than marble.

It has, alſo, frequently a cryſtallized ſtructure, and ſometimes, though not always, ſmall black dots may be ſeen diſperſed through it. In the countries, where this lime-ſtone is found, the lime is generally diſtinguiſhed, from its effects in agriculture, by the farmers, as *hot* lime, in oppoſition to the purely calcareous, which they term *mild*.

To aſcertain, by chemical means, the compoſition of a lime or lime-ſtone, ſuſpected to contain magneſia, the following is the eaſieſt, though not the moſt accurate proceſs. Procure a Florence flaſk; clean it well from oil by a little ſoap lees, or ſalt of tartar and quicklime mixed; and break it off, about the middle of the body, by ſetting fire to a ſtring tied round it, and moiſtened with oil of turpentine. Into the bottom part of this flaſk put 100 grains of the lime or lime ſtone; and pour on it, by degrees, half an ounce of ſtrong ſulphuric acid. On each affuſion of acid a violent efferveſcence will enſue; when this ceaſes, ſtir the acid and lime together with a ſmall glaſs tube or rod, and place the flaſk in an iron pan filled with ſand. Set it over the fire, and continue the heat till the maſs is quite dry. Scrape off the dry maſs; weigh it; and put it into a wine glaſs, which may be filled up with water. Stir the mixture, and when it has ſtood half an hour; pour the whole on a filtering paper, placed on a funnel, and previouſly weighed. Waſh the inſoluble part with water, as it lies on the filter; and add the waſhings to the filtered liquor. To this liquor add a ſolution of half an ounce of ſalt of tartar in water; when, if magneſia be preſent, a very copious white ſediment will enſue; if lime only, merely a ſlight milkineſs. In the former caſe, heat the liquor, by ſetting it in a tea-cup, near the fire; let the ſediment ſubſide; pour off the clear liquor, which may be thrown away; and waſh the white powder repeatedly with warm water. Then pour it on a filter of paper, the weight of which is known; dry it; and weigh. The reſult, if the lime-ſtone has been ſubmitted to experiment, ſhews how much carbonate of magneſia was contained in the original ſtone; or deducting 60 per cent. how much pure magneſia 100 parts of the lime-ſtone contained. If the burnt lime has been uſed, deduct from the weight of the precipipitate 60 per cent; and the remainder will give the weight of the magneſia in each 100 grains of the burnt lime.

2. *Analyſis of Marls.*

The ingredient of marls, on which their fitneſs for agricultural purpoſes depends, is the carbonate of lime. It is owing to the preſence of this earth, that marls effervesce on the addition of acids, which is one of their diſtinguiſhing characters. In aſcertaining whether an efferveſcence takes place, let the marl be put into a glaſs partly filled with water, which will expel a portion of air contained mechanically in the marl; and thus obviate one ſource of fallacy. When the marl is thoroughly penetrated by the water, add a little muriatic acid or ſpirit of ſalt. If a diſcharge of air ſhould enſue, the marly nature of the earth is ſufficiently eſtabliſhed.

To find the compoſition of a marl, pour a few ounces of diluted muriatic acid into a Florence flaſk; place them in a ſcale; and let them be balanced. Then reduce a few ounces of dry marl into powder; and let this powder be carefully and gradually thrown into the flaſk, until after repeated additions, no further efferveſcence is perceived. Let the remainder of the powdered marl be weighed; by which the quantity projected will be known. Let the balance be then reſtored The difference of weight, between the quantity projected, and that requiſite to reſtore the balance, will ſhow the weight of air loſt during efferveſcence. If the loſs amount to 13 per cent. of the quantity of marl projected, or from 13 to 32 per cent. the marl aſſayed is calcareous marl, or marl rich in calcareous earth.

Clayey marls, or thoſe in which the argillaceous ingredient prevails, loſe only 8 or 10 per cent. of their weight by this treatment; and ſandy marls about the ſame proportion. The preſence of much argillaceous earth may be judged, by drying the marl, after being waſhed with ſpirit of ſalt, when it will harden and form a brick.

To determine, with ſtill greater preciſion, the quantity of calcareous earth in a marl, let the ſolution in muriatic acid be filtered and mixed with a ſolution of carbonate of pot-aſh, till no further precipitation appears. Let the ſediment ſubſide; waſh it well with water; lay it on a filter, previouſly weighed; and dry it. The weight of the dry maſs will ſhow how much carbonate of lime the quantity of marl, ſubmitted to experiment, contained.

3. *Analyſis of Soils.*

The following rules for determining the compoſition of a ſoil, are copied from the intereſting tract of Mr. Kirwan already referred to.

"*Firſt*, In dry weather when the ſoil is not over moiſt nor dry, let a ſurface of 16 ſquare inches be cut through to the depth of 8 inches; this may be effected by a right angle ſpade, formed for this particular purpoſe. Of the parallelopiped thus dug up, the two inches next the ſurface ſhould be cut off to get rid of the graſs, and the greater part of the roots; we ſhall then have a ſolid 6 inches long, and 16 ſquare at the end=96 cubic inches. Let this be weighed*; its weight will ſerve to find the ſpecific gravity of the ſoil; for if 96 cubic inches weigh n pounds, 1728 (a cubic foot) ſhould weigh x pounds, and x divided by 75,954 will expreſs by the quotient the ſpecific gravity of the ſoil. To render this and the ſubſequent operations more intelligible, I ſhall illuſtrate each by an example: Suppoſe the 96 cubic inches to weigh 6,66 pounds then 1728 cubic inches ſhould weigh

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* Troy weights are generally more exactly made than avoirdupois, and therefore ſhould be preferred. A cubic foot of pure water weighs 75,954 troy, very nearly, or 62,5 avoirdupois pounds, at the temperature 62°.

$$120\text{lb. and}\ \frac{120}{75{,}954}=1{,}579.$$

" 2*d*. The earth being weighed, is next to be broken down, and freed from all ſtoney ſubſtances above the ſize of a pippin, and the remainder well mixed together, to render the whole as homogeneous as poſſible; then weigh the ſtones that were picked out, and find the proportion belonging to each pound of the reſiduary earth; call this the *ſtoney ſupplement*, and denote it by *S*. Thus if the ſtones weigh 1 lb.=12 oz. the remainder, or mere earth, muſt weigh 5,66 lb. and if to 5,66 lb. there belong 12 oz. of ſtone, to 1 lb. muſt belong 2.12014 oz. or 2 oz. 57,66 grs.=1017,66 grs. This then is the ſtoney ſupplement of each ſucceeding pound=S.

" 3*d*. Of the earth thus freed from ſtoney matter, take 1 lb.—*S*. (that is in the above caſe 1 lb.—2 oz. $57\frac{2}{3}$ grs.) heat it nearly to redneſs in a flat veſſel, often ſtirring it for half an hour, and weigh it again when cold. Its loſs of weight will indicate the quantity of water contained in 1 lb. of the ſoil. Note this loſs, and call it the *watery ſupplement*=*W*. Suppoſe it in this caſe 100 grains.

" 4*th*. Take another pound of the above maſs freed from ſtones, deducting the ſtoney and watery ſupplements; that is, 1 lb.—S—W, or in the above caſe 1 lb. —2 oz. $57\frac{2}{3}$ grs. for ſtone, and—100 grs. for water; conſequently 1 lb.—2 oz. $157\frac{2}{3}$ grs. Reduce it to powder: boil it in four times its weight of diſtilled water for half an hour; when cool, pour it off, firſt into a coarſe linen filter to catch the fibrous particles of roots, and then through paper, to catch the finer clayed particles diffuſed through it: ſet by the clear water, add what remains on the filter to the boiled maſs; if it be

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